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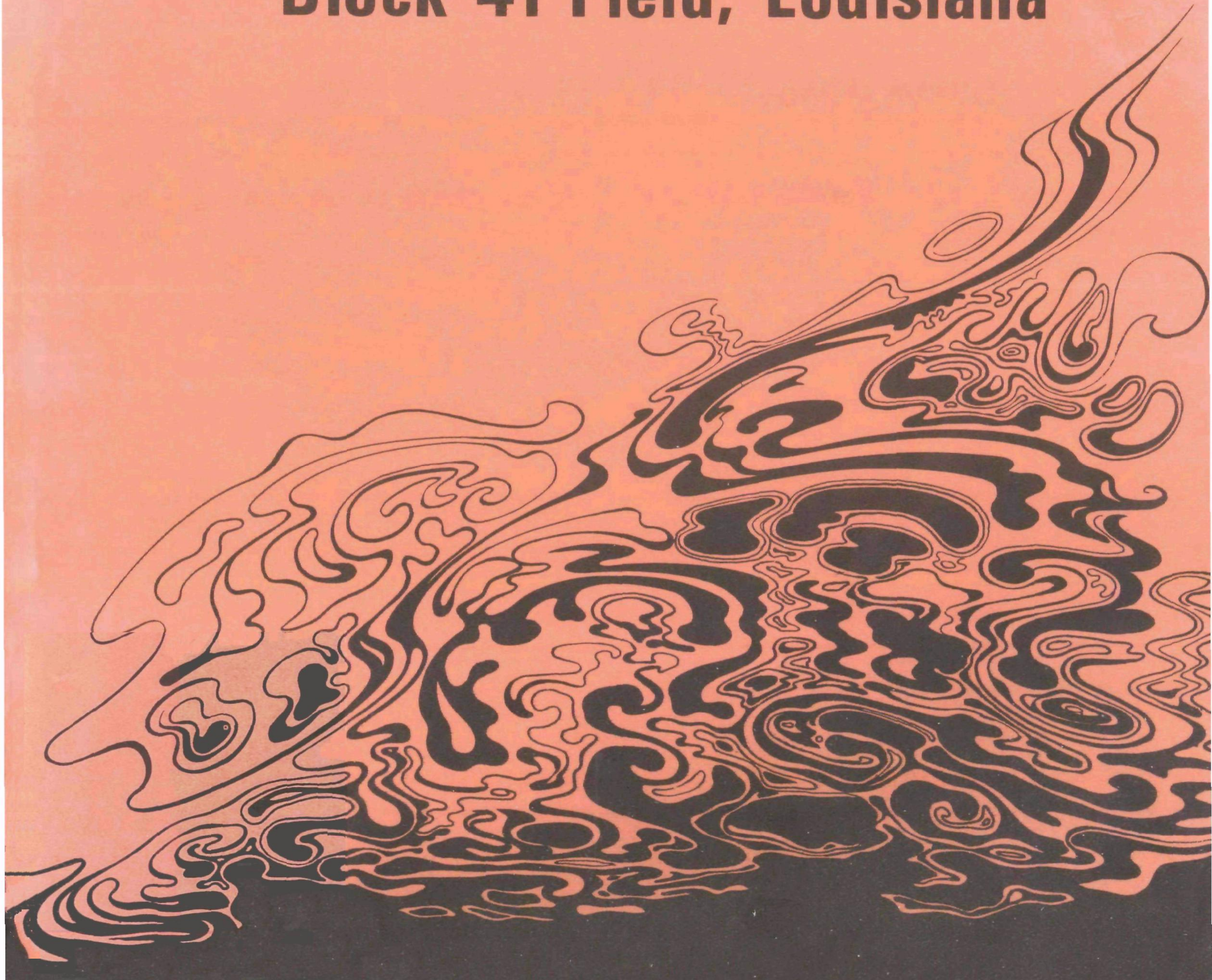
Oil Pollution Incident Platform Charlie, Main Pass Block 41 Field, Louisiana



ENVIRONMENTAL PROTECTION AGENCY • WATER QUALITY OFFICE

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OIL POLLUTION INCIDENT

PLATFORM CHARLIE, MAIN PASS BLOCK 41 FIELD

LOUISIANA

by

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for the

WATER QUALITY OFFICE
ENVIRONMENTAL PROTECTION AGENCY

Project #15080 FTU

Contract #14-12-860

May 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price $1.25
Stock Number 5501-0130

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ABSTRACT

A documentation team from Alpine Geophysical Associates, Inc. observed the Chevron spill incident and interviewed key personnel concerned.

The facts, observations and reports are included herein.

Little damage to the environment was observed, mostly due to a combination of fortuitous circumstances. Considerable knowledge was gained concerning the physical limitations of spill control in open water.

This report was submitted in fulfillment of Profect Number 15080 FTU, Contract 14-12-860, under the (partial) sponsorship of the Water Quality Office, Environmental Protection Agency.

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1.0 INTRODUCTION

For roughly eight weeks (February 10 to March 31, 1970), wells on the Chevron Oil Company platform Charlie in the Main Pass Oil Field (MP41C) were out of control, spewing crude oil and natural gas into the air from the platform level. For one month of this time, fire consumed almost all the escaped oil. When the fire was extinguished on March 10, oil began escaping onto the waters of the Gulf of Mexico. All the wells were brought under control by March 31, three weeks later, ending the oil spillage.

On March 21, the Federal Water Quality Administration (FWQA) contracted with Alpine Geophysical Associates, Inc. to document the observed and potential pollution effects, and pollution control efforts connected with the above casualty for the purpose of preparing a timely report. The objective was to put a small multi-discipline team of scientists and engineers in the field to make observations and conduct interviews with participants in the casualty, while the events were still freshly in mind.

For the most part, the information presented herein is culled from interviews with Federal, State and local agencies involved in the casualty or with the resources of the area. Off-the-record interviews were held with a representative of the Chevron Oil Company. Information was culled from numerous technical publications, newspapers and from public records. The scope of the work precluded original research, however, some original conclusions were necessarily reached by the Documentation Team, as this report was prepared prior to the release of the results of many of the researchers working on the problem.

Numerous photographs were taken by the Documentation Team, some of which are presented in the report.

This is the second casualty report of this type, sponsored by FWQA, the first being a documentation of the Santa Barbara Spill.(1)

1.0 REFERENCES

(1) Battelle Northwest, July, 1969, "Review of Santa Barbara Channel Oil Pollution Incident" Water Pollution Control Research Series, DAST 20.

2.0 SUMMARY AND CONCLUSIONS

2.1 Regional Background

The Main Pass Field is located off the Louisiana coast roughly 10 miles east of the Mississippi Delta. The Delta is an extensive low-lying swampy region laced with innumerable waterways. The principal economic asset of the region is petroleum and petroleum products; with the exploitation of biological resources, such as commercial fishing, hunting and trapping, running far behind.

The area is used extensively for recreational hunting and fishing and there are numerous private camps for those purposes; but there are no developed bathing beaches, resort hotels, or "high priced" vacation homes.

Both the Delta and the offshore areas have many active oil fields with oil rigs and structures visible everywhere. A complex pipeline network runs along the water bottom. There is a good deal of activity associated with these fields; vessels, helicopters, drill rigs, etc., as well as a noticeable amount of chronic oil pollution from these oil field structures and activities.

The Delta waters, and particularly the Breton and Chandaleur Sound areas are recognized as vital spawning and nursery grounds for many of the commercial, sports, and non-exploited fish, shellfish and other marine plants and animals of the Gulf of Mexico. The Delta lands and islands are important habitats for birds (both migratory and local), mammals and other animals. There are a number of important State and Federal wildlife refuges and sanctuaries in the area.

2.2 Source Description

Block 41 of the Main Pass Field was reportedly producing roughly 65,000 bbls. per day of oil and 100 million cu. ft. per day of gas before the fire. Platform Charlie (MP41C) with five of its 12 wells active, was producing about 3,000 bbls. per day of oil and 1.1 million cu. ft. per day of gas. Production was from two Miocene sands at about 6,000 feet and 9,000 feet.

The oil produced was an extremely light gravity (about 36 API) paraffin based crude and appears brownish in color as it comes out of the well. Oil/gas separation is done on the platform, with the oil/water and gas pumped separately ashore to refineries. The platform was completely automated (unmanned).

The total amount of oil spilled on the water in this incident, is estimated by the Documentation Team to be between 35,000 and 65,000 barrels; roughly equivalent to the amount spilled at Santa Barbara during a similar time period (3 weeks), and an order of magnitude less than that carried by a supertanker the size of TORREY CANYON.

2.3 Events

Platform MP41C caught fire accidentally on February 10, 1970. Eight wells were "wild" and burning on this platform for one month (until March 10th) while concentrated efforts were made to extinguish the fire.

Serious oil pollution started several days before the fire was extinguished when large quantities of water were played on the fire to cool the platform. Pollution continued until March 31st, when the last wild well was brought under control.

When the casualty occurred, the Regional Contingency Plan was activated; however, since the Chevron Oil Company assumed full responsibility for the control and clean-up of the spilled oil, the Regional Response Team was placed on stand-by status to observe and advise only.

A massive logistic effort was initiated by Chevron to mobilize vessels, equipment, personnel, and supplies, shortly after the fire started; when oil pollution started, a considerable control force was in operation.

Fire at the platform was a constant hazard due to the presence of gas and the volatile fractions of the crude oil. Several times after March 10 the platform burst into flames which were quickly extinguished by water jets. No serious injuries to personnel were reported as a result of the casualty in spite of the hazardous work of capping the wells and controlling the fire and pollution.

2.4 Movement of the Oil

Platform MP41C stands in about 40 feet of water in an area of complex interactions between the turbid fresh waters of the Mississippi River and the saline shelf waters of the Gulf of Mexico. During the spill, the river was high, nearing flood. The winds were generally rotating with occasional frontal systems giving sustained winds from a single direction.

Oil and gas blew out of the wells at platform level forming large air plumes, some of which were deflected downward. High pressure water jets containing dispersants, hit the oil in the air and on and under the platform. As the oil moved away from the platform it took on these easily distinguished modes.

1. A narrow reddish-brown surface string of thick oil thought to be a water-in-oil emulsion or "mousse".

2. A Widening surface plume or "slick" with characteristic oil film colors depending on local thickness.

3. A widening creamy yellow sub-surface plume, thought to be an oil-in-water emulsion formed by chemical dispersion of the oil.

The mechanism of oil movement prevailing at the time of the casualty can be found in Section 6.2, Movement and Behavior of the Escaped Oil. To summarize: (1) Wind was the major factor controlling surface movement; (2) certain oceanographic phenomena provided barriers protecting areas of the land mass.

The oil was never reported to have reached the Delta, and was stopped at least on one occasion by the fresh water barrier (rip). Oil reached the vicinity of the islands on several occasions, but only one instance of any large amount on the beaches is reported. No oil is reported to have reached the back bays of Breton Sound presumably having been flushed by natural currents from the Sound on the two occasions that it was observed to have reach the Sound.

The older slicks were not observed for long after a wind shift. It is felt that the shifting winds combined with natural dispersion, a high rate of evaporation and biodegradation, was responsible for the rapid disappearance of the oil, and the prevention of the build-up of an oil "sea". It is not known how much oil was effectively dispersed by chemicals at the platform and put into the water column, nor what the ultimate destination or fate of this emulsion was. Most of the surface oil is thought to have moved seaward, caught up in the eastern Gulf of Mexico circulation loop and carried to the ESE. A considerable amount of the water-in-oil emulsion or "mousse", was picked up by skimmer boats in good weather, or dispersed by prop wash in both good and moderate weather.

2.5 Control of the Oil

Chevron had mobilized a force of approximately 60 vessels, 250 men and a large amount of equipment and chemicals, spending an estimated 2.5 million dollars for pollution control alone.

2.5.1 Mechanical

A first line of defense consisting of an anchored barge line with containment booms and skimmers to protect the islands and bays had little success.

The second line of defense, made up of chase-skimmer boats and a skimmer barge, was more successful, as was a later mobile system made up of two 500 lengths of "Navy" boom held by tugs in a "Vee" with a skimmer boat at the apex. Eight or nine vessels were used to disperse heavy ropes of oil with propeller wash.

The third line of defense made up of fast, shallow draft boats, lightweight booms, and straw barges with mulchers; mobilized to protect and clean up the back bays of Breton Sound was only partially utilized in a clean up and stand-by operation on Breton Island.

The best of the mechanical containment and skimmer devices used are generally considered to have been quite effective in 1-2 foot seas, 50% effective in 3-4 foot seas, and essentially useless in anything rougher.

The best of these devices were "home made" by Chevron at the scene.

After initial attempts to contain all the oil around the clock, control efforts were limited to daylight efforts in good weather only, and directed at picking up or dispersing the heavy red-brown ropes of oil.

Two factors influenced the control operations significantly:

1. The casualty occurred in an active oil producing area, where personnel, heavy marine equipment, and logistic support were readily available.

2. The fire gave the control team sufficient working time to mobilize. It is estimated that there was at least a one-week lag between the commencement of the logistic effort and the arrival at the site of any appreciable amount of oil spill control equipment and specialists.

The mobilization effort dramatized the lack of available stand-by oil pollution equipment capable of coping with a large disaster.

2.5.2. Chemical

About 1,000 barrels of Corexit and 500 barrels of Cold Clean, both chemical dispersants, were used at the platform as a safety measure. Chemicals had been disapproved for use as an anti-pollution measure, however, Chevron had USGS permission to use chemicals at the platform for hazard control. The chemicals metered into the intake manifold of the jet barge and platform pumps were thereby diluted to lower concentrations prior to application on the oil. (A maximum of 300 ppm. from the barge.)

The amount of chemicals used were capable of fully dispersing at least 7,500 barrels of oil based on a very conservative estimate of dispersion rates (1 part chemical to 5 parts oil); and as applied, could have dispersed considerably more than this amount, (manufacturer recommends 1 part chemical to 10-50 parts oil).

2.6 Surveillance

Numerous over-flights by cognizant government agencies were made on a routine basis, weather permitting, to make visual observations of the spill. An aerial search for damaged wildlife and shore pollution was also conducted. Normal aircraft navigation was used and "eyeball" estimates of slick length and width, etc., were made. Chevron made numerous surveillance flights and used a precise navigation system.

The U. S. Geological Survey initially made several test remote sensing flights and then made routine aerial photography flights during the entire incident, using a mobile tracking radar based in Venice for navigation. The U. S. Coast Guard in cooperation with NASA made a series of simultaneous remote measurements during the daylight and dark of March 16. Remote Sensing, Inc. of Houston, Texas, also made a number of multi-sensor flights over a period of several days.

Most of the remote data taken is considered to be of high quality, but this information was not available to the control team in near-real time. All groups apparently just flew patterns along the "newest" slick, with no attempt made to delineate older slicks, or slicks from other operations in the area.

2.7 Property Damage

The only reported damage to land occurred on Breton Island, (oil on beaches and in lagoons, March 3rd and March 16th), which was subsequently observed to be completely cleaned up and restored to its original condition.

Damage to vessels has not been reported, except for some isolated net damage in the shrimp fleet, and some dirty sails among the yachtsmen sailing offshore.

It was reported that sales of Louisiana shellfish and fish declined during the period of the spill because of buyer fear of obtaining off-taste food. No evidence has been reported of real damage to sea food.

2.8 Biological Damage

From reported gross observations and data gathered by local and federal agencies, there is little or no evidence of any acute biological problems which were precipitated by this oil spill. No reports were found of fish, birds or other animals killed by this spill.

The shrimp, oyster, crab and menhaden fisheries suffered no reported acute damages, although a number of law suits by fishermens groups have been initiated against Chevron for alleged specific damages to the fisheries. The potential of a public health hazard due to sudden enrichment of the area with spilled oil, leading to the formation of blooms of noxious organisms has been postulated.

What is still to be determined, however, are the possible long-term ecological effects of acute exposure to the polluting oil and chemical residues in the area.

3.0 REGIONAL BACKGROUND

3.1 Geographic and Demographic Setting

Chevron's Main Pass Block 41 oil field is located in the Gulf of Mexico east of the Mississippi River delta. The closest point on the mainland from Platform Charlie is the Main Pass river mouth area 10 miles to the southwest. Breton Island lies about 9 miles northwest. The geographic coordinates of this platform are 29° 23' 59" North and 89° 00' 54" West. According to Louisiana statutes this is within offshore Plaquemines Parish. The Mississippi-Gulf outlet canal termination is immediately adjacent to the East. Water depth is approximately 40 feet. (See Figure 1).

Coastal areas in this region are largely deltaic, that is, low-lying swampy areas characterized by mangrove growth with no clearly defined shoreline. Water and land are intermingled giving the effect of literally thousands of tiny islands, water passages in a veritable maze, and biological growth surpassed in few areas of the world.

Few people live in this immediate area. The only centers of population are largely supported by oil production and in fact some are wholly-owned by various major oil companies and their large contractors. Venice, on the river north of the Main Pass, is the closest town. The few families living along the coastlines support themselves by fishing and hunting.

The entire lower delta area suffered severe damages during hurricane Camille in August, 1969. Breton Island, Grand Gosier Island and other offshore islands changed landform dramatically during the storm.

New Orleans, with a metropolitan population close to 1,000,000 is about 65 miles northeast of Platform Charlie. It is the only city of any size within this area.

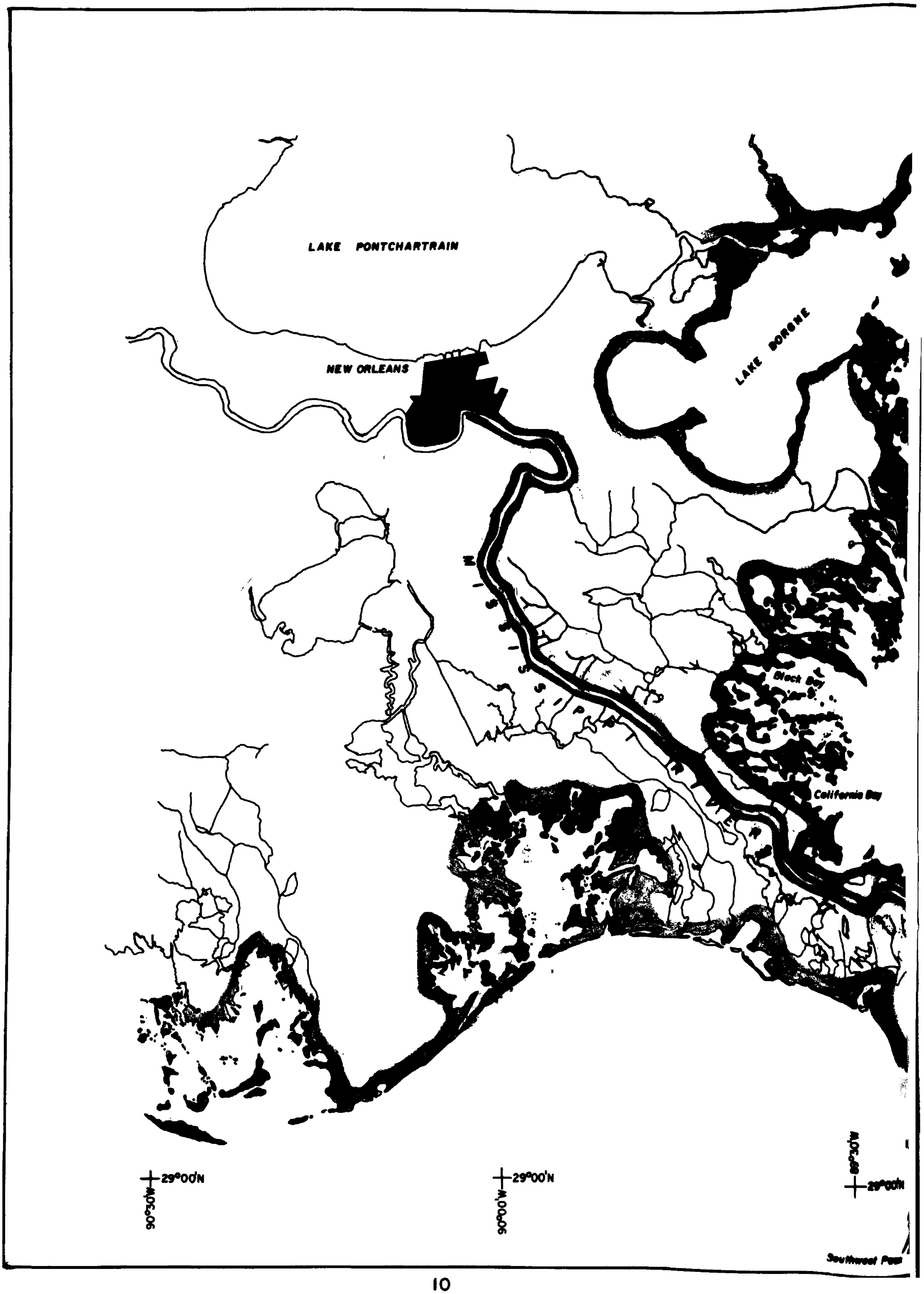
3.2 Resources of Direct Economic Value

3.2.1 Mineral Resources

Oil is the primary natural resource of this area. Plentiful production is encountered both offshore and onshore all along the Louisiana coastline. Other mineral production includes sulfur, salt and sand and gravel.

3.2.2 Commercial Fisheries

Of major importance in the state economy is the commercial fishing undertaken in Louisiana waters. In addition to edible and rough fish, the oyster and shrimp production are both major industries. See Appendix C for a description of the biological resources.


LAKE PONTCHARTRAIN
NEW ORLEANS
LAKE BORGNE
MISSISSIPPI RIVER
Black Bay
California Bay
29°00'N
90°30'W
29°00'N
90°00'W
89°30'W
29°00'N
Southwest Pass

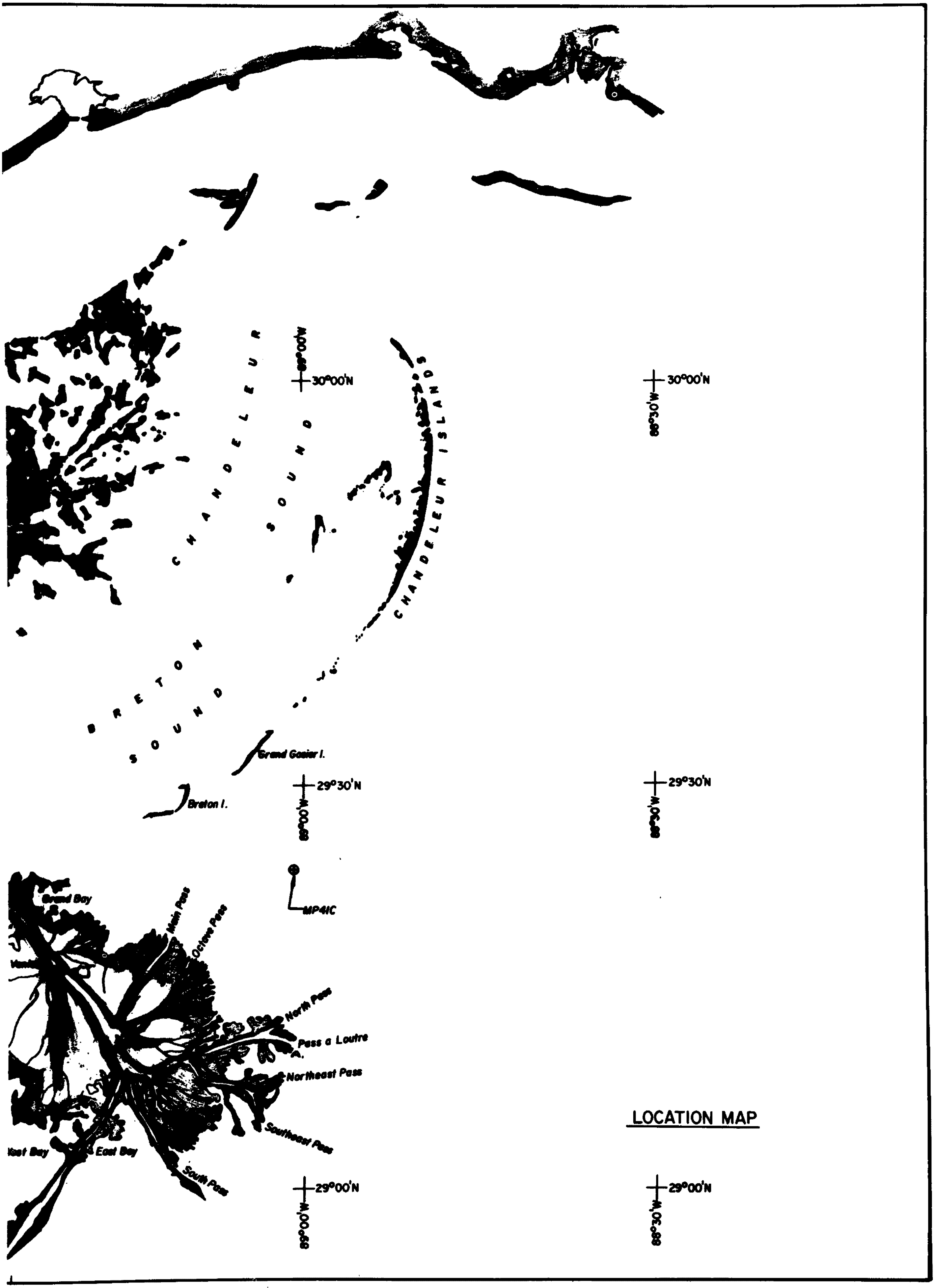

CHANDELEUR SOUND
CHANDELEUR ISLANDS
BRETON SOUND
Grand Gosier I.
Breton I.
MP41C
Grand Bay
Main Pass
Octave Pass
North Pass
Pass a Loutre
Northeast Pass
Southeast Pass
South Pass
East Bay
30°00'N
89°00'W
88°30'W
29°30'N
29°00'N
LOCATION MAP

FIG. 1

3.2.3 Lumber

Timber production for lumber, newsprint and naval stores is a major industry of the area north of Lake Ponchatrain.

3.2.4 Recreational Resources

The coastal area of Louisiana does not have developed bathing beach areas. Swimming and related activities are limited. The main water related activities are yachting and fishing. For information on sport fishing, see below. Recreational boating is mostly inshore, Lake Pontchartrain, etc. or relatively far offshore. Navigation in the immediate onshore area is quite difficult because of the numerous shifting shoal areas and the confused bay and island pattern.

3.2.5 Hunting and Fishing

The coastal areas are largely marsh, forming one of the great hunting and sport fishing areas of the U. S. Migratory water fowl are abundant particularly during the winter months. Some species hunted are Mallard, Black Duck, Redhead, Canvas back, Greater Scaup, Lesser Scaup, Ring-necked Duck, Ruddy Duck, Large Mergansers and Hooded Mergansers. Geese are represented by Canada Geese, Whitefront Geese, Blue and Snow Geese. In addition to waterfowl, dove, wild turkey, quail, woodcock and snipe are taken by sportsmen.

Deer hunting is best in the northern sections of the state but is undertaken also in the delta areas. Squirrel and rabbit are game animals as well.

Recreational fishing is practiced both in fresh water, inshore in brackish and salt water and offshore in shallow and deep water.

Sports fishermen in Louisiana take Bass, Bream, Crappie and catfish in fresh water. Shallow salt water fishing yields Sea trout, Red Snapper, Flounder, Pompano, Bluefish, Specks, Lemonfish, Tarpon, Drum, Sheepshead and Croaker. Further offshore, catches include Marlin, Dolphin, Swordfish, Tuna, Sailfish, Wahoo and Amberjack. Appendix C contains additional information relating to hunting and fishing.

3.3.6 Summary of Biological Resources in the Immediate Area of the Chevron Oil Platform MPC41

The area to the west of the MP41C platform consists of extensive brackish water marshes which serve as major bird feeding and resting grounds in addition to being a valuable public sport hunting area. To the west and north are refuge areas for birds and other local animals which also serve a public natural parklands. Northwest of the rig lie the most important oyster seed beds in the State serving the Louisiana commercial oyster fisheries, and north of the rig are extensive bird sanctuary areas serving migratory bird populations in the northern hemisphere. The inshore waters serve as nursery grounds for shrimp and menhaden which support a part of the extensive local commercial shrimp and fish meal industries. In the deeper waters and surrounding many of the rigs, are substantial concentrations of snapper, pompano and other species which support a large local sport fishing industry. In addition, the Chevron oil platform is located in the area of major shrimp and menhaden harvests for the fishing fleets operating out of Venice and Empire, Louisiana.

A full description of the biological resources of the East Delta area is given in Appendix C of this report.

4.0 REGIONAL OIL PRODUCTION

4.1 Brief History of Drilling

The first offshore well in Louisiana waters was drilled in March, 1938 in the area now known as the Creole Field, about 1.5 miles from the coast line. Significant development of offshore hydrocarbon deposits did not commence until November, 1947, when the Ship Shoal Block 32 field was found about 12 miles off the Louisiana coast line. (1)

Widespread development of these offshore resources did not take place until, in 1953, the Submerged Lands Act and the Outer Continental Shelf Lands Act were passed. (Appendix D of this report elaborates the jurisdictional aspects of the offshore fields.) In spite of the costly and difficult problems of operating offshore, there has been a rapid movement to offshore provinces. Two reasons for the shift to the Gulf are the success ratios (Fig. 2) and the reserves found. From 1953 to 1967, the average success ratio for exploratory wells drilled in the Gulf of Mexico was 26%, compared with a ratio for onshore wells of about 18%.

From 1955 through 1966, the cumulative production of crude oil and condensate was about 1.3 billion bbls. Simultaneously, there was a 2.35 billion bbls. cumulative increase in the reserves, which amounted to about 50% of the total U. S. increase.

The Main Pass Block 41 Field was leased by Chevron in August, 1947. The discovery well was drilled in January, 1957, and the first production was in April, 1957. As of February, 1968, there were 151 oil wells, 14 gas wells, 26 dry holes and 14 other wells in the field. Cumulative production to January 1, 1967 was 14,453,717 bbls. of oil, 8 bbls. of condensate, 14,923,569 Mcf of Casinghead gas and 14,849,015 Mcf of natural gas.

4.2 General Geology of Main Pass Area

No publications on the geology of the Main Pass Block 41 Field have been found. The State of Louisiana records indicate that below platform MP41C there are two main producing zones, one at about 6,200 ft. and one at about 9,200 to 9,700 feet, both of Miocene age.

Main Pass Block 41 Field is a shallow anticline partially fault-controlled, according to informal reports.

The Gulf Coastal plain, a segment of the Mesozoic-Cenozoic coastal geosyncline of Eastern North America, is a tremendous wedge of generally southward dipping sediments. Cenozoic rocks are generally deltaic nearshore. Fluviatile, marginal, and deltaic sediments grade gulfward into darker facies, principally clays, carbonates and fine sands. The principally clastic nature of those deposits reflects

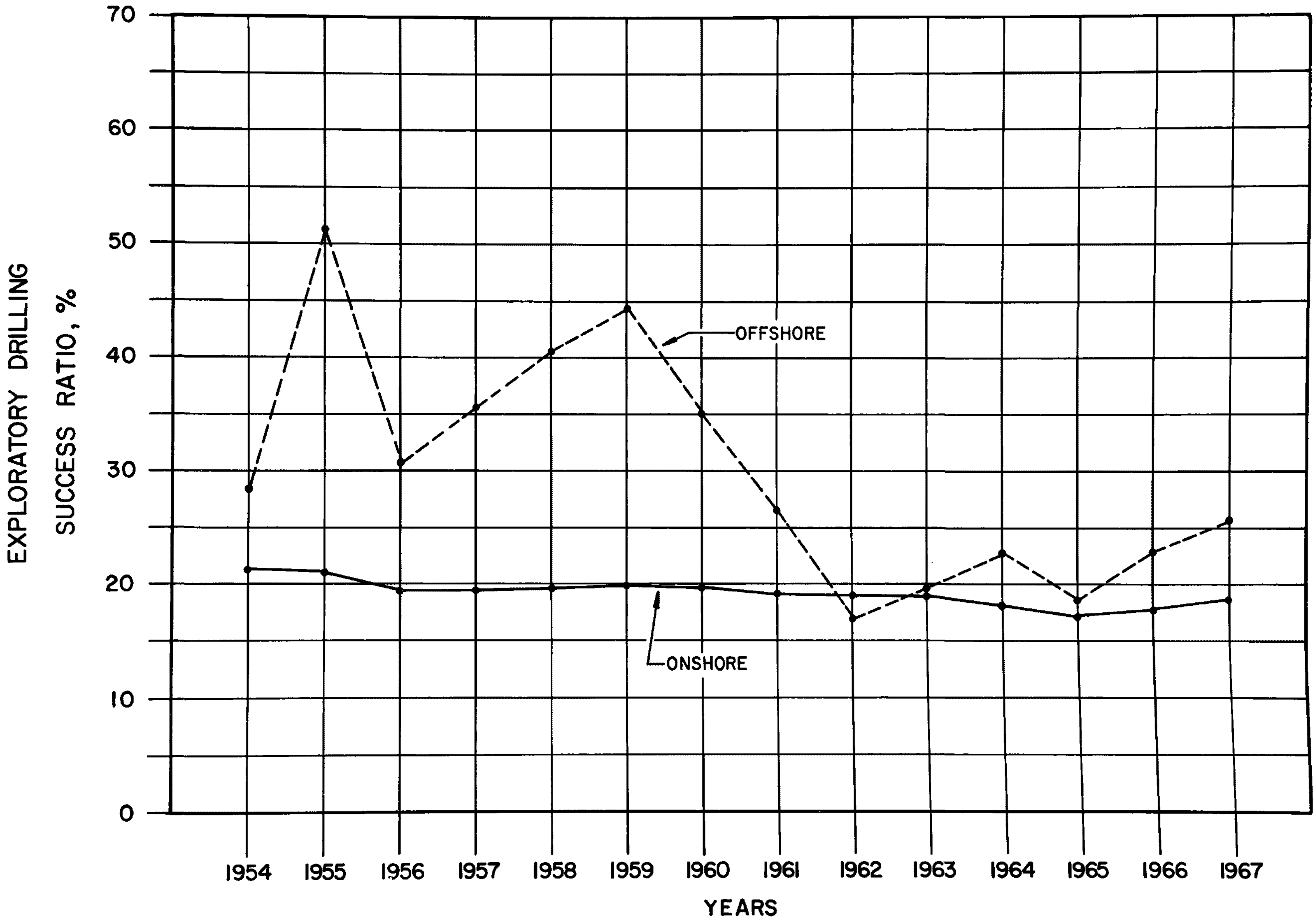


FIGURE 2 -SUCCESS RATIO

continued orogeny in the cordillera of Western North America. More than 25,000 feet of sediments accumulated in this period.

During the Miocene period more than 20,000 feet of arenaceous, argillaceous sediments accumulated in this basin. These rocks are also deltaic - fluviatile in character, grading to thick marine shales, marls and sandstones offshore.

The continuity of these strata is interrupted by major systems of normal strike faulting, down warping of isostatic adjustments and by piercement salt domes and deep seated salt ridges. The throw of the faults can range up to 6,000 feet with variable orientation.

The presence of igneous rocks (of the Mesozoic) is important because porosity developed by alteration of basalts to serpentine can serve as a reservoir for hydrocarbons.

The fault systems are quite commonly interrupted by salt domes, suggesting that the domes may have been positioned at depth by the faults and that they grew in those zones in association with weaknesses created by the faulting and the great increases in sedimentation which occur across many of the fault zones.

The entire Miocene-Pliocene sequence is characterized by rapid thickening Gulfwards of individual units and by equally rapid lithologic changes.

Hydrocarbon accumulations are found in many beds of this sequence. Traps are formed structurally by folding, mainly in diapiric folds, around the flanks of salt domes, where the piercement dome acts as a cap rock, stratigraphically where lithologic changes serve as a reservoir with a cap rock of the same age but different in lithology and along faults.

Commonly, the area west of the delta is characterized by circular fields associated with salt domes. East of the delta folding and faulting seem to be the common field control.

4.3 General Data Regarding the Platform

Previous to the fire of 10 February, the Chevron platform at Main Pass Block 41 was a typical non-attended offshore production platform. The platform was the termination for 22 wells - 10 dual completions and 2 single satellites - of which only 5 were in production at the time of the accident. The platform (56 X 71 ft.) was supported on cylindrical piling in about 40 feet of water, and consisted of a center section where the well casings terminated, and two opposing cantilevered sections. One of these sections contained a compressor, and the other supported a helicopter platform and separator equipment. These wells, previous to the time of the fire, were producing about 3000 bbls. of oil and 1.1 million cu. ft. of gas per day (Table 1) or about 5% of

TABLE 1 (4)

Summary of Wells on Platform MP41C

Well & Zone	Total Depth	Production Zone	Net Oil Production	Choke in 64ths	Sand & H_2O	Tubing Pressure	API Gravity	Maximum Efficient Production	Gas/Oil Ratio	REMARKS
C-1	9743	9432-61	670	18	C	1000	34	1500	1392	
C-1D	9743	6206-09	Off							
C-2	9507	9218-26	770	18	C	1700	34	1500	172	
C-2D	9507	6013-17	Off							
C-3	9880	9628-38	Off					100		
C-3D	9880	8208-25	Off							
C-4	9648	9340-52	Off							
C-4D	9648	6176-78	265	20	C	150	28	130	305	
C-5	9967	07-4-08	Off					100		
C-5D	9967	8310-14	Off							
C-6	9776	9508-9606	959	18	C	2175	35	1500	2595	
C-6D	9776	6380-88	Off					320		
C-7	9602	9354-62	Off							
C-7D	9602	7934-42	265	10.5	C	1800	33	190	3207	
C-8	9125	8912-20	Off					100		
C-9	9411	9232-40	Off					700		
C-9D	0411	7834-48	Off							
C-10	9263	9140-48	Off					700		
C-10D	9263	7736-43	Off					200		
C-11	9397	9304-12	Off					100		
C-11D	9397	7935-41	Off							
C-12	9271	9102-10	Off					700		

All Wells on Production were flowing by Reservoir Pressure
Total Maximum Efficient Production 7840
Oil Production in Bbls./Day
Sand & H_2O: C = Clean
Gas/Oil Ratio: G/O = Cu. Ft. Gas/BBl. of Oil

the total production of the entire Block 41 field (65,000 b/d of oil and 100 million cu. ft./day of gas) (1). The maximum efficient production (MEP) rate as reported to the State of Louisiana in January, 1970 was 6,750 bbls per day. The oil/gas separation was done on the platform but no attempt was made to separate oil and water which were pumped ashore together.

There is some unofficial indication that between the time of the last State report and the casualty, the production picture on the platform had changed from that described above.

4.4 General Petroleum Chemistry of this Field

The oil produced from Platform C varied in API gravity from 28° to 35° with the heavier crude from a shallow production zone. According to a Bureau of Mines analysis of Main Pass Block 41 crude oil, the percentages of various fractions present are given in Table 2.

This then is a very light crude oil. It will spread very rapidly on a water surface and lose a large part of its volatile fractions to evaporation or emulsification. The fractions forming a heavy slick on water will probably be less than 70% of the total within a short period of time and may be as little as 50% after 24 hours. (5) Evaporation in this case is accelerated by the blowing out of the oil into the air. Being a paraffin base crude, the residuum will probably not be as viscous as an asphalt base crude. Asphalt, from Handbook of Chemistry Tables, has a specific gravity of 1 to 1.8 and the residuum could sink when all of the volatiles are gone. The paraffin residuum in this crude will continue to float since no fraction has a specific gravity as high as water provided it is not sunk by other agents (sediments).

4.5 Chronic Oil Spills

Spill incidents in the area, prior to the fire on platform Charlie, have not been individually logged. Spills varying in size from a few gallons to many barrels are endemic to the Gulf of Mexico. One chronic problem is when water/oil separation is done on the platform, some oil remains in the water, and if dumped over the side produces a visable slick. In the land areas, waste water settling ponds are commonly used to further separate the oil from the waste water, and in many of the off-shore platforms the waste water is pumped ashore with the oil for separation in the refineries. However, many near shore installations, in the sounds and back-bays were observed to pump oily waste water overboard.

Oil appears on the Gulf waters from numerous other operations connected with the drilling the operation of the wells. U. S. Coast Guard reconnaissance flights report 3 to 7 pollution incidents every week, and many of these are identified with the company or individual responsible. However, the cause of each incident is not generally

TABLE 2 (5)

Crude Petroleum Analysis

Fraction	Per Cent	Sp. Gr.	°API
Light Gasoline	2.0	0.701	70.3
Total Gasoline Naptha (including Light Gasoline)	15.8	0.766	53.3
Kerosene Distillate	12.1	0.811	43.1
Gas Oil	23.5	0.845	36.1
Nonviscous Lubricating Distillate	18.8	0.857-0.874	33.7-30.5
Medium Lubricating Distillate	9.6	0.874-0.885	30.5-28.4
Viscous Lubricating Distillate	1.4	0.885-0.886	28.4-28.1
Residuum	18.7	0.928	21.0

documented and action to prevent a re-occurence is not often taken.

In addition to the chronic oil spills connected with oil production operations, some surface oil spots reported in the Western Gulf of Mexico are thought to be caused by natural oil seeps. (2)

4.6 Amount of Escaped Oil

In all major spills, the amount of oil spilled is perhaps the most disputed statistic. In this incident, published estimates have run from 1,000 barrels per day to 3,000 barrels per day.

The actual amount of oil spilled will probably never be accurately known, however, there are ways to estimate it. Reference is made to Table 1, copied from State records, which lists among other data the net oil production (N.O.P.), and the maximum efficient production (M.E.P.) for each well on the platform that was producing at that time. Eight of these wells are known to have been wild after the casualty.

Fig. 3 graphically indicates the sums of the M.E.P., and the N.O.P. for the period after the fire was extinguished (March 10) and shows a decrease as the successive wells were shut down. The total M.E.P.s is taken as the maximum possible flow and the sum of the N.O.P. as the minimum. The reasoning for this is developed in the following paragraphs.

Theoretically, if the tops of the "Christmas trees" (control head of the wells) were removed, oil would flow through the well tubing at a rate determined by the diameter of the tubing, the pressure of the production zone and various friction effects along the whole length of the tubing. The allowable production is controlled by a choke (in the case of MP41C, the chokes are about 1/4 inch diameter). The tubing on most of these wells is 2-3/8 inches, some a bit larger. The maximum efficient production rate for a well in simple terms is the rate at which the well can flow without a marked loss of reservoir pressure.

It was reported that tests after the casualty was under control, showed no significant loss of pressure in the MP41C wells, and this is taken to mean that the total M.E.P. for the wells was not exceeded. This total is the high number plotted in Figure 3.

The low number is developed by assuming that the production choke in the well head remained intact, and that oil escaped at the allowable rate. It is not known if this was or was not the case in this incident (the valves presumably being also intact under those circumstances but inoperable due to heat deformation). Certainly when the well heads were blown off to facilitate capping of the tubing, this was not true. If this number is accepted as the minimum possible flow, one has to qualify it somewhat by the reduced flow of oil, particularly in C-6 during the flow of water and mud from the bottom relief well.

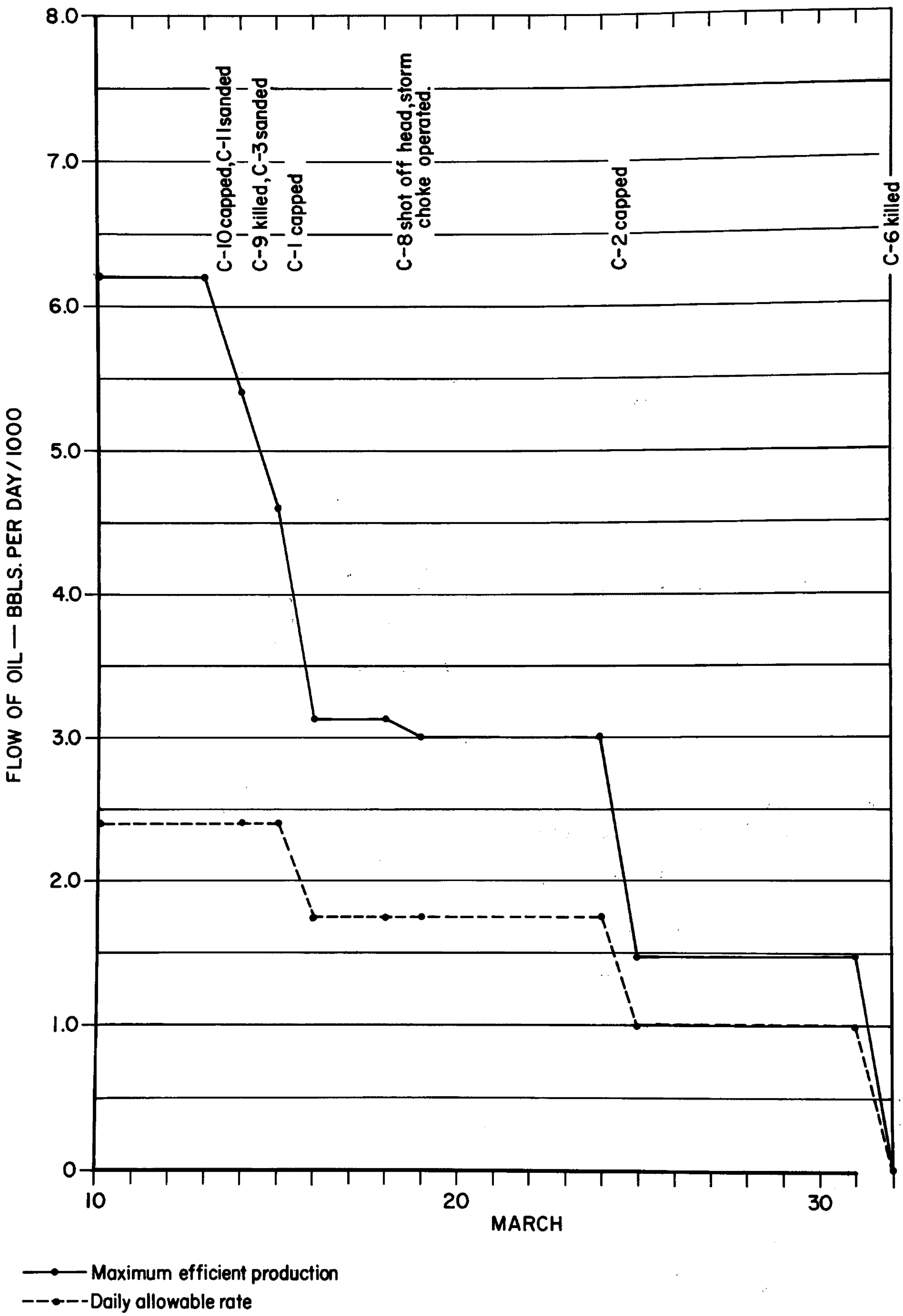

8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
FLOW OF OIL — BBLS. PER DAY / 1000
C-10 capped, C-11 sanded
C-9 killed, C-3 sanded
C-1 capped
C-8 shot off head, storm choke operated.
C-2 capped
C-6 killed
10
20
30
MARCH
Maximum efficient production
Daily allowable rate

FIG. 3

The above reasoning leads to a maximum figure of roughly 65,000 barrels and a minimum of 35,000 barrels of oil escaped during the period March 10 through March 31, or from the time the fire was extinguished to the time the wells were completely shut down. This minimum number is somewhat higher than an unofficial oil company estimate of 20,000 barrels. The estimates average for the above period roughly 1,000 to 3,000 barrels per day and confirm the published figures.

As a matter of interest, the maximum figure is an order of magnitude less than the oil carried by TORREY CANYON class vessels, and is about the same order of magnitude spill for a comparable period of the Santa Barbara incident.

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5.0 SUMMARY OF EVENTS

5.1 General

This section is a synopsis of the Situation Reports (SITREPS) of several Federal Agencies' and newspaper articles, and is included to give the reader a quick review of events at the spill.

At approximately 3 a.m. on February 10, 1970, a fire occurred on Chevron's Platform Charlie in the Main Pass Block 41 field. Since this was a completely automated platform, the incidents leading up to the fire were not observed. A service man had been on the platform at about 2:30 a.m. of that day.

An initial attempt to control the fire was made by two Halliburton vessels, equipped with monitor nozzles. (1) When it became apparent that this was not successful, it was decided to call in Paul "Red" Adair and his team.

Estimates of the possible duration of the fire, even at this time, ranged up to more than a week, mainly because it would be necessary to construct an auxiliary platform to serve as a working base at the site.

The U. S. Coast Guard assigned a vessel to remain at the scene to provide assistance as necessary and to provide a base for the representative from the office of the Captain-of-the-Port, New Orleans, who was acting as On-Scene Commander.(2)

At a meeting with the U. S. Coast Guard and State officials in New Orleans on February 11th, Chevron assumed responsibility for control and clean up of the wild wells. On this basis, the USCG and the other Federal agencies represented would act in an advisory and observational capacity only.

Oil company personnel immediately started building and assembling equipment to be used to be used to fight the fire, control the wells and to pick up the spilled oil.

Consultants brought in to assist included Mr. William Altenberg, Altenberg, Kirk and Company, Portland, Maine; skimmer and pollution control expert; Mr. Silcox, engineering consultant from California; and Mr. Curtiss Wright, representative of Johns-Manville.

Mr. Harlan Wood of the Department of the Interior, Public Information Office said that pollution experts estimated that 1,871 bbls. of oil per day were being consumed by the fire.(3) This estimate apparently was made before a determination was made of what wells were involved.

Equipment arrived at Venice each day during this period in preparation for controlling the fire and the oil slick which would result when the fire was extinguished. Meanwhile, almost all of the escaping petroleum was burned as it arrived at the surface, the only residue being some ash and carbon from the fire.(4)

Bad weather delayed construction and placement of the auxiliary work platform until the 24th of February. Meanwhile the work barge, JIAFRA and the derrick barge, GEORGE R. BROWN, were at the site. The JIAFRA was previously rigged with pumps and monitor nozzles (used as a pipeline jet barge) and was utilized on this job to spray cooling water on the burning structure. The cooling effect precipitated some petroleum which formed occasional small slicks around the platform.

Bad weather delayed preparations to extinguish the fire on February 25th and 26th. However, it was announced that blasting to control the fire would take place on March 1st. By this time, Chevron had established most of their "first line of defense"--the barge and boom semi-circle about 1,500 feet from the rig.

Permission was received from USGS on the 27th of February, 1970 to use chemical dispersants on and under the platform in order to reduce the fire hazard after the fire was extinguished.

The attempt to blow out the fire was again postponed on March 1st because of difficulties in rigging the protective water sprays on the work platform.

Chevron had available and in position by March 3rd the drill rigs, MR. ARTHUR and PENROD 51. These were scheduled to drill relief holes to the producing formation to kill the flow of some of the wild wells. The drill barge, S-66, was scheduled to arrive on March 4th.

Some oil reached shore on Breton Island on March 4th. This was estimated at 20 bbl. but was not positively identified as originating at the Chevron incident.

On this date all containment and control equipment was in position and the control effort was scheduled for March 5th. Unfavorable weather forced postponement again on March 5th and the weather continued bad until the first blowout attempt was made on March 9th. The fire re-ignited in 6 minutes from some unknown cause. Initial estimates said about 1,000 bbl./day of oil were escaping while the wells were extinguished.(2)

The next attempt scheduled for the following morning, March 10th, was successful. USCG and USGS situation reports show that the fire was extinguished at about 11:30 a.m. The boom line was reported to be holding successfully until about 12:30 p.m. but oil had passed this line by 3 p.m. and the skim boats and barges were in use. According to other observers, the barge line was not effective when the fire was extinguished due to unrepaired wave damage.

On March 11th, the oil slick was estimated to be moving north, northwest at 0.8 to 0.9 knots. The skim barge was relatively effective but could not cope with the amount of oil coming out of the well. Bad weather was moving in but the wind was shifting to the north blowing the oil offshore.

Secretary Hickel flew over the scene of the spill on March 12th. USCG reports that a bird survey of the Chandeleur Island Chain counted 16,000 birds. Skimmers were not in use because of bad weather.

The first wells were closed in on March 13th. Well C-11 died at noontime probably because it sanded up below ground. Well C-10 was capped by personnel on the platform at 4 p.m.

A frontal passage produced high winds and seas damaging or destroying most of the containment booms in use around the rig.

USCG reports on March 14th show dispersants, "Cold-Clean" and COREXIT being used to reduce fire hazard. The detergent chemicals help to clean the rig surfaces and to break up the oil into fine droplets. Well C-9 was killed by mud pumped down one of the relief holes drilled near Platform C. Well C-3 also ceased flowing on March 14th either because it sanded up or from the relief well effects.

Shell Oil Company's experimental chemical, "Oil Herder", was tested during this period. Results of the testing showed that the chemical had to contact the water surface before it contacts oil in order to be effective. The results of the tests were inconclusive as it was thought that chemical dispersants used at the platform had an adverse effect on the "Oil Herder".

Skimmers worked during the daylight hours of March 14th, collecting 2,400 bbls. of oil-water emulsion. According to USGS reports, about 5,700 bbls. of emulsion had been skimmed to this date. These, and the following pick-up estimates are from the boats and have not been confirmed.

Well C-1 was capped from the platform on March 15th in the afternoon. During the day skimmers were reported to have collected 2,800 bbls. of emulsion. All barges in the containment line were back in position with booms. The skim barge was being used between barges 3 and 4.

During March 16, weather conditions deteriorated to the point where skimmers could not work. Bad weather continued through the 17th, including a squall line which virtually destroyed the barge boom line. A survey was undertaken in the Breton National Waterfowl Refuge which showed that no harm had been incurred.

On March 18th, the barges damaged on the previous day were taken to Venice for repair. The weather was foggy but 1,000 bbls. of emulsion reportedly were skimmed.

Well C-8 was controlled on March 19th at 1 p.m. The well head was shot off and the storm choke came into operation. The skim boats and barge were said to have picked up 2,100 bbls. of emulsion on this day for a total to date of 15.5 thousand bbls.

By March 20th, The Louisiana State University, Coastal Studies Institute team of Dr. Murray, Dr. Smith and Dr. Sonu completed their studies around the platform. Skimmers were working and picked up 2800 bbls. of emulsion according to reports.

The USCG situation reports give test figures of better than 50% oil in the recovered emulsion.

An analysis of the skimmer operation was made on March 21st showing an overall efficiency of 11% for the barge and 8.3% for the boats in percentage of oil in total liquid recovered.(2)

No skimming was possible on March 22nd due to high wind and seas. No change occurred on the platform until March 24th when Well C-2 was capped at 2:30 p.m. Skim boats worked on March 23rd, picking up 2800 bbls. of emulsion and on March 24th with 1900 bbls. collected.

On March 25th, the last uncontrolled well, C-6, re-ignited spontaneously but was almost immediately extinguished by water sprays. No skimming was possible on this day or on March 26th, 27th or 28th. During most of this period high seas were breaking up and dispersing the oil slick.

C-6 again re-ignited on March 28th at 9:03 p.m. and burned until extinguished with water at 3:10 a.m. on March 29th. It again ignited at 2:30 p.m. and was extinguished at 3:00 p.m. No injuries were sustained during the periods of re-ignition. Skim boats worked on March 29th collecting 2900 bbls. of emulsion.

Two relief wells had been drilled to the producing vicinity of C-6 by this time and the platform crew was attempting to cap the well. No change was seen until March 30th when the flow volume was gradually reduced by the fluids being pumped down a relief well.

Well C-6 was finally controlled at 7:20 a.m. on March 31st when the flow was stopped by the relief well fluids. All wells were capped and checked by April 1st and 2nd and the pollution control center was secured.

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6.0 DESCRIPTION, MOVEMENT AND BEHAVIOR OF THE OIL

This section is composed primarily of interpretations of visual observations and photos made by the Documentation Team, and are included to provide background information to others working with data and samples from the spill.

6.1 Description of the Escaped Oil

The oil escaping from the wells blew out into the air from the platform level. The air plume of the major producer, Well C-6, was a dull brown color. This well was covered by a baffle for part of the time, which deflected the oil downward under the platform. The other major well, C-2, blew a yellow plume high into the air. Water mixed with chemical dispersants was sprayed on the oil, the platform, and the water by high pressure monitors mounted on the jet barge, JIAFRA, and in the auxiliary work platform.

The oil took on three basic modes once clear of the platform:

a) The most noticeable was a bright reddish-brown band of thick oil roughly 10 feet wide, extending for many miles and taking on various ropey configurations if left to itself. These ropes of oil remained roughly the same width regardless of distance from the platform. This appears in the aerial photographs as described, and is seen as a white (warm) line in the IR scanner records made in the daytime (Fig. 11).

It is felt that this is the "mousse" or water-in-oil emulsion described in previous oil spill reports. It is not known whether this is an effect of the chemicals used, or is due to the high pressure water hitting the oil, or both.

It is this oil that the containment and skimmers operations concerned themselves with almost exclusively.

b) The next aspect was the oil slick itself. This varied in color from dull gray, to irridescent, to a silvery sheen. This was the widening surface (two dimensional) plume or slick described in the situation reports as the "rainbow", and had considerable variations in thickness and appearance. This shows up to its full width on the "UV" photos. Narrower (thicker) parts of it show up black (cool) on the IR records (Fig. 11).

c) The final major mode was a creamy yellow sub-surface plume emanating from the platform. This plume widens and diffuses with distance from the platform. It is felt that this is an oil-in-water emulsion with the oil dispersed into very fine droplets by the water-chemical mix.

This yellow plume is in the upper water column (fresh turbid water only several feet thick) and travels along with this water body. It is seen on certain days to end abruptly at a water boundary east of the platform, where the fresher water meets the more saline Gulf waters. It is not known if the oil-in-water emulsion travels along the water boundary, or if it enters the shoreward moving salt water which travels under the thin layer of fresh water in this vicinity. (See Appendix A for oceanographic description of the area.)

All three of these oil units move from the platform in the same general direction (that of the wind) with the ropey strings and the yellow plume taking different positions relative to each other on different days, but always associated with the wide slick. This variation in position is not unusual as one would expect that the ropey string would react primarily to the wind direction, and the yellow subsurface plume would react to a combination of wind driven currents and other currents. The "rainbow" slick would tend to grow from both these features as clean oil detaches from either emulsion (oil-in-water, water-in-oil).

There were local variations in texture and color of the surface oil, the most significant being large light brown oil lumps containing vegetation and other debris, associated with a slick at the "rip" where the river water meets the Gulf water.

This slick at the "rip" is believed to have formed when the wind blew the oil toward the west. The "rip" acts as a barrier to the surface water and oil, protecting the shores of the Delta. It is not known how much wind is necessary to overcome this barrier. The oil slick elongates along the direction of the "rip" and stays in close contact with the river water.

A number of these oil "varieties" were sampled by FWQA. It is felt that much of value can be learned concerning the fate of the oil on the water from proper testing of these samples, and correlation with the airborne data.

6.2 Movement and Behavior of the Escaped Oil

Reference is made to Appendix B of this report for a tabulation of meteorological, oceanographic, and slick description data during the period of this oil spill; and to Appendix A which discusses the oceanography of the East Delta region.

Based on field observations of the oil and preliminary examination of the aerial photos, the Documentation Team has reached the following conclusions:

a. The wind direction, strength, and duration determined the direction and distance of travel of the surface and sub-surface oil plumes from the platform. This was modified by tidal currents, and other circulation features.

b. The major fresh-salt water boundary, the "rip"--a convergence zone, along the eastern side of the Mississippi Delta acted as an effective barrier to surface oil driven from the platform westward toward the Delta.

There was a temporary or intermittent boundary to the east of the platform which appeared as a sharp change in turbidity. When the oil plume extended eastward, this boundary, when present, was found to be a barrier to the oil suspended in the sub-surface (brackish) layer. However, the plume of oil floating on the surface readily crossed it with little or no distortion.

c. No effective water barrier exists between the platform and the islands and sounds, however, a net outward flow due to the river discharge tends to flush the sounds as do other factors.

d. With winds from the north or west, the circulation pattern of fresh and brackish surface water moving from the sounds seaward helps flush the sounds and protect the back bays.

e. Winds from the south or east drive oil towards and into the sounds; however, they set up the secondary circulation system, which also flushes the surface waters from the sound toward the sea, again protecting the back bays.

f. The condition of chronic oil spills in the area, along with the tremendous amount of "nutrients" brought down the Mississippi River maintains a large seed population of oil degrading organisms in this vicinity. These organisms appear to act quite rapidly in the biogradation of the oil from this spill.(1)

Since preparation of this review, a report and analysis of oceanographic observations made during the period of the spill was prepared under contract to the U. S. Coast Guard by the Coastal Studies Institute of LSU. The conclusions of this group do not differ markedly from those of the Documentation Team.(2)

The oil plume was almost always observed to leave the platform in the same general direction as the wind. Quite often photos showed a sharp hook in the plume. This was associated with an abrupt wind change. Other photos showed the plume to make a large gentle curve. This is felt to be the effect of rotating wind directions. On March 24 and 25, the southerly winds were blowing the oil generally northward toward the islands. On the 26th the wind shifted from west of south (225°) to west of north (330°) starting a new plume toward the SSE and displacing the old plume in the same direction. This same effect is also illustrated in Figure 11 and Figure 12 where the IR scans taken 3 hours apart show the plume shift coinciding with a wind shift occurring between the two records.

It is likely that a detailed examination of the aerial photos (particularly) the mosaics) would indicate other reactions of the plume to other circulation effects such as the tides, particularly when the winds are low; however, the USGS mosaics required additional work at the time of this writing.

As described in a previous section, most of the surveillance from the air and water concerned itself with the most recent slick, with nothing appearing in the reports regarding oil more than a couple of days old. It was not certain at the time whether this was due to the older oil moving off to sea and thus out of mind, or if the oil is dispersed or otherwise reduced beyond recognition in a few days. At this time, it appears that both factors were at work.

The longest observed slicks were noted when the wind blew from the same quadrant for a long period of time. It is felt that when the wind would shift to a new direction, the wind would add another dimension to the spreading of the surface oil (e.g. If the wind shifts 90 degrees, spreading perpendicular to the old slick axis is increased). Thus, the old oil is subject to very rapid spreading, which would aid dispersion by wave action, aid bio-degradation and possible spread the oil beyond the point of visual recognition; possibly accounting for the reported "disappearance" of the old oil some time after the wind shifts.

Only sustained and strong winds from the south and southeast would threaten the islands and the sounds. This occurred only three times during the high oil flow period, and will be discussed later. The winds from the east were sustained enough to threaten the Delta only one time; however, as discussed, the "rip" protected this shore. All the other times, the winds were from the wrong direction, too weak, or not sustained enough to threaten the islands and sounds. The oil at these times merely moved to sea and into the general Gulf circulation pattern which carried it to the east southeast, or further to sea.

Oil slicks in general are observed to respond to the wind. This slick coming from MP41C was no exception. The actual processes involved in wind induced flow are complex. They involve the drag of the wind on the surface, sea-surface roughness (waves) and the Stokes velocity of waves, and the formation of windrows. But there can be little doubt that wind-induced speed of the topmost layers of water and of an oil slick, will be significantly larger than the 2 or 3 per cent of wind speed generally indicated by instruments that average current speeds over several thin layers slightly below the surface.

Since southerly and easterly winds aid the establishment of the secondary axis of net surface drift which would have a flushing action in Breton Sound, while northerly and westerly winds would tend to keep oil out of the sound, almost all winds are at least somewhat favorable with respect to protection of this area. With regard to pollution of the beaches, any wind having an on-shore component would move nearby oil onto a beach. But during the period of greatest danger, between the extinguishing of the fire and sealing of the last well, winds were, for the most part, too light or too variable in direction to move oil from MP41C to Gosier and Breton Islands or the mouth of Main Pass, the nearest land. For example: if the oil moves at 4% of the wind speed, it would take about 15 hours for steady 15-knot winds to bring pollution from the platform to the nearest beaches. During the most hazardous time there were only four periods during which the wind direction was fairly constant and unfavorable. These were:

PERIOD	AVERAGE SPEED	TOWARDS
1200Z 10 Mar - 1800Z 11 Mar	11 knots	Breton Island
1200Z 16 Mar - 1200Z 17 Mar	22 knots	Breton Island
0600Z 25 Mar - 0600Z 26 Mar	10 knots	Breton & Gosier Is.
0600Z 27 Mar - 1800Z 28 Mar	18 knots	Delta & Main Pass

An examination of the aerial records for these periods indicate:

1. On March 11, the IR scan records made by Remote Sensing, Inc. show the oil going northwest for approximately 20 miles from the platform between Breton and Grand Gosier Islands into Breton Sound (Figure 11); and (Figure 12) shows the slick translating eastward after a wind shift.

2. On March 16, both USGS and USCG aerial records showed the oil up to Breton Island and possibly into the sound.

3. On March 26, a map made by USGS aerial surveillance group shows the oil up to Grand Gosier Island, but moving away again due to a wind shift.

4. The Delta area, including Main Pass, is protected by the convergence zone. March 28, the oil was observed to flow westward until meeting the "rip" then north and south along the edge of the "rip".

Pollution of the beaches was directly reported in the official situation reports for March 16 only. There are also reports of cleanup operations on Breton Island using straw which was subsequently burned.

Of course, the picture is far more complex than described above, because any particular wind will move not only oil issuing from the source while the wind is blowing, but also the oil that has been moved to other locations by previous winds. This previously emitted oil would have undergone a degree of spreading and dispersal, depending on the local conditions and the length of time it had been on the surface.

Tidal currents are another large factor in the movement of the oil. These would tend to deflect oil approaching the delta, but would tend to move oil into or out of the sound depending on whether the tide was flooding or ebbing. However, if tidal currents were the only factor, the net result should be an increasingly large oil slick, with a periodically oscillating centroid, which alternately extends tendrils of oil spreading into Breton Sound and partially retracts them. Pollution of the beaches above the high water mark would not take place without some wind or wave action.

Tidal currents in the vicinity of MP41C can have speeds up to 0.8 knot. Since this is a maximum value, since the nearest land is about 8 nautical miles away, and since the flooding current persists for no more than about 13 hours, it is not likely that tidal currents along would be able to move a particle of oil from the platform to the land. However, this too, is an over-simplification, because of the large spreading of the oil, even on undisturbed water.

Probably the main factor in preventing extensive pollution of the shore - and of considerable significance in the flushing of Breton Sound - was the river discharge. Its action was two-fold. First, by creating a convergence zone, where saline gulf water flows under fresh river water, it produced a barrier to the surface oil between the Delta shore and the source. On several occasions the oil slick was reported to have extended westward up to the convergence zone, and then to have spread out along it. Second, because of the river discharge, there is a net seaward transport of surface water. The primary direction of this net transport is eastward from the Delta, and this had a flushing action on the area around the source of the oil. The secondary direction of net seaward transport is through Breton Sound and just south of Breton and Gosier Islands, which would have aided the flushing of these areas.

If the river had been at low discharge stage, the convergence zone would probably still have existed to protect the Delta shore. But the flushing action would have been less effective, and the turbulence spectrum may have been different, altering the dispersion rate.

Two types of oil can be in suspension: that which had been emulsified by physical breakup of the oil into tiny droplets, and that which had been emulsified by chemical means. Most of the former would rise to the surface within a few hours and become part of the surface oil slick. The latter may be presumed to have remained in suspension. Its fate depended on whether it penetrated to the deep, up-stream flowing salt water layer, or remained in the seaward-flowing, fresher surface layer. Oil in the deep layer could conceivably find its way into Breton Sound in a highly diluted state, and possibly remain there for a considerable time. Also, it could conceivably move quite close to the Delta shore. However, because the river was at high discharge stage, it is not likely that the oil could have moved into the river outlets even if it could have reached the vicinity of the passes.

Since the chemicals used formed a bio-degradable emulsion, the chemically emulsified oil would probably, after a time, be metabolized by the micro-organisms in the water.

The oil suspended in the surface layer was probably gradually flushed out to sea through the primary and secondary axes of net seaward transport. One set of photos shows that, on at least one occasion, the emulsified oil in the surface layer stopped at a turbidity boundary which the surface oil passed over. There was no line of floating debris associated with this turbidity boundary and surface oil easily passed over this line, so it could not have been a convergence though there may have been one at that place earlier.

Unfortunately, no information is available regarding the percentages of oil at different depths.

In the open Gulf of Mexico, the currents flow northward from the Yucatan Straits and diverge just south of the Mississippi Delta, part flowing westward along the Texas coast, the other part flowing eastward along the coast of Mississippi, Alabama, and Florida. In the area south of the Delta, between the diverging tongues, the surface currents are mainly related to the local winds. Figure 15, from Scruton (3), after Leipper (4), shows the current pattern in the Gulf of Mexico. The eastward flowing tongue entrains water emerging from the area east of the Delta. Surface water having salinity less than 35 parts per thousand is not found beyond the 1,000 fathom contour further from the coast than 70 statute miles. Thus, the Mississippi (and east Delta) drainage does not spread beyond the continental shelf (4).

Gaul (5) reports that the "DeSoto Canyon (south of Pensacola) generally appears to be the eastward limit of intrusion of Mississippi River water except when major wind systems exert significant influence on the surface circulation. This suggests that there must be a net surface transport westward around the Mississippi Delta that is confined to the shelf". Walsh (6) says that the westerly-flowing tongue of the Gulf current enhances the littoral currents leaving the Delta, while the easterly branch normally seems to have little influence on the surface waters. However, deeper than 15 meters, there is a definite northeasterly flow affecting the area from South Pass to the east.

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7.0 CONTROL OF THE OIL

7.1 Discussion of Operations

When the casualty occurred, simultaneous efforts were undertaken on three fronts to provide a capability for extinguishing the fire, stopping the flow of oil and controlling oil pollution.

Two methods for extinguishing the fire were undertaken:

(a) cooling the platform and putting the fire out with water,
(b) using explosives to choke off the oxygen supply.

When the attempt at the first method failed, the rigging necessary to proceed with the first alternative was undertaken. Construction was started on a work platform from which firefighting and well capping operations could be performed. An analysis of the situation had indicated that this was a major spill and a large scale effort would be needed to cope with the situation. Chevron began mobilization of all the expertise and equipment it considered would be in any way helpful in combating the spill. They called in experts on the extinguishing of oil well fires and engaged consultants from many other fields including weather, oceanography, oil containment, skimming, ecological effects and pollution; advice and support was solicited from the cognizant State and Federal Agencies.

On the basis of this pooling of its own capabilities with the input from the consultants, Chevron began to assemble the tools and work force needed to contend with various phases of the problem. From McDermott they obtained the jet barge, JIAFRA, to spray water on the platform and keep it cool. The GEORGE R. BROWN, a Brown & Root derrick barge, was moved into the area to support the work platform construction effort. At the same time three drill rigs, Chevron's S66, Penrod's PENROD 51 and Corals' MR. ARTHUR were contracted to drill relief wells in an attempt to choke off the flow of oil from below. Chevron outfitted one of its LST crew ships with additional communications equipment and moored it close by as an on-site command center for directing the control effort. From within its own organization it mobilized supervisors, engineers and workmen and assigned them to various tasks.

Although the extinguishing of the fire and drilling of the relief wells were by themselves major efforts, they were familiar problems with known solutions to any major oil company such as Chevron. However, the control of large scale oil pollution at sea was not an every day occurrence and there was a lack of practical experience to draw on. Previous spills (Torrey Canyon and Santa Barbara) gave every indication that the problem was extremely serious and offered no easy solution. There was a distinct lack of off-the-shelf equipment available to aid in combating a spill of this magnitude. It was extremely urgent that something be done immediately for, once the fire was extinguished, the pollution would increase dramatically. There was little time to theorize over the ideal approach, so every avenue which gave any promise at all of producing results was implemented and a work force delegated to pursue it.

Various types of booms, skimmers, absorbents and chemical dispersents were assembled. None of the equipment or materials had any previous history of being totally effective in containment and clean up of oil spills, so no single approach could be fully relied upon. It was hoped that from the assembled equipment a system could be developed to contain and clean up the spilled oil.

Three mechanical "lines of defense" were developed, and the equipment and manpower required for each mobilized.

1. A line of anchored barges interconnected with containment booms and equipped with skimming equipment.

2. Several chase-skimmer boats and a skimmer barge to collect oil which passed through or by-passed the line of barges.

3. A number of fast shallow draft boats, lightweight booms, and barges with straw and mulchers to protect the bays and beaches.

The use of chemical dispersants for anti-pollution purposes were expressly forbidden by the FWQA; however, the use of these chemicals for safety purposes in the immediate vicinity of the platform was approved by USGS. Thus, for the purpose of preventing serious accidents at the platform during the well capping operations, Chevron prepared effective means for the application of chemical dispersants at the platform. See Section 7.5.

Most of the available supply of commercial containment booms in the U.S. was purchased by Chevron and routed to its operational base in Venice. Personnel had to be trained in its deployment and operational peculiarities. A blueprint of the "Navy" boom was obtained and a barge was outfitted for its manufacture on an assembly-line basis. A survey of the field showed that no skimming equipment capable of operating in the open sea was available anywhere, so skimmers had to be built from designs worked up on the spot by William Altenburg. Methods for rigging the skimmer boats had to be worked out, and the boats outfitted with booms, outriggers, separation tanks, pumps, etc. A barge was outfitted for skimming, and a large adjustable weir was designed and built for it. The seven barges which were to protect the NW sector were outfitted with anchors, tanks, skimming equipment, pumps, etc. Sections of commercial boom were fitted to fill the gaps between barges. Although the fire was not extinguished until approximately one month after it started, the pollution control program was under constant pressure from the beginning as it was thought, from day to day, that the fire would be put out.

An indication of the effort expended by the pollution control groups is given by the inventory of equipment at the scene or mobilized in Venice by February 19th.

Tow boats	4
Cargo barges	2
Work boats	1 - 250'
Work boats	2 - 150'
Work boats	2 - 80'
Oil barges	4
Spill control boom	
Johns-Manville	2600'
TT	1500'
Slickbar	2200'
Boom handling equipment	
Inflatable buoys	100
Styrofoam buoys	50
Steel buoys	6
Anchors	140 - 40 lb.
Anchors	6 - 500 lb.
Nylon cord	30,000'
Anchor chaim	4,400'
Skimmers (Altenburg type)	4
Pumps	8 - 400 GPM
Pump	1 - 300 GPM
Pump	1 - 200 GPM
Pump	1 - 650 GPM
Chemicals	
Corexit	80 drums
Chemical Spray Boats	2 - 100'
Chemical Spray Boat	1 - 90'
Absorbents	
Straw	20,700 bales
Ureafoam pads	450 - 19" x 60"
Mulchers	2

It was soon realized that wind and sea were the main deterrents to any type of spill control in the open sea, and the equipment needed must be of an order of magnitude larger than that used in protected waters. The difficulties of handling larger equipment in rough weather compounds the situation, and where light gear can be manhandled, means must now be provided to use auxiliary power such as winches, cranes, falls, etc. Also in open water it is not feasible to use small work vessels. The list of equipment previously given indicates that at that time the smallest vessel in use was an 80-footer.

One aspect of the SANTA BARBARA and TORREY CANYON spills which took on major proportions failed to occur in the MP41C spill. The former spills caused major damage to wild fowl and a concerted effort to mobilize men and equipment to prevent this in the Gulf was made. One reason for the barge array was to protect the Breton Island Bird Sanctuary. Men were permanently stationed on the island to keep the birds away and clean traces of any oil that came ashore. The men were provided with firecrackers and shotguns with blanks in order to keep any birds from landing if any accumulation of oil had built up on the beaches. Large amounts of straw were landed on Breton for absorption of the oil and incinerators were provided for disposal of the oil soaked straw. This mobilization effort was luckily never utilized to any great extent.

One way of reducing the amount of water pollution would have been to collect the oil at the platform before it reached the water surface. This would have required construction of a device for making an oil/gas separation of the escaping crude and diverting the oil to a nearby collection point. Chevron did indeed construct such a device but it was never used. It was completed just as capping operations for C-6 were commencing and it was decided to go ahead with the capping attempt rather than install the collector and depend on choking off the well from below.

It is interesting to note that of the eight wells which had to be stopped, four were shut off from the platform and four were choked off from below, either by drilling auxiliary holes and injecting fluid into the oil producing strata or from natural causes, (sanding-up). Well C-6, which caused most of the pollution, was shut off by drilling. If the decision had been made to make no attempt at capping but to collect the oil and wait for the wells to be choked off from below, the overall pollution might have been reduced. The decision made at the time was to use every available method to stop the flow of oil as quickly as possible, and cope with the pollution after the oil was on the water.

The engineering and field implementation of Chevron's pollution control program were major efforts. It is estimated that this aspect alone of the total work directed at re-establishing control of the oil from Platform MP41C involved the use of approximately 250 men with as many as 60 vessels in use at certain times and an expenditure of 2.5 million dollars. Of distinct advantage to Chevron in the situation was the fact that the platform was located in an area where there were people and equipment available to make immediate response. This area of the Gulf has been the center of offshore oil production for years and although there was little expertise in controlling oil spills of this magnitude, the background of related experience was there.

7.2 Booms

The effective control of an oil spill depends in large measure on the ability to prevent spreading of the oil on the water surface. An obvious approach to the prevention of spreading is the use of booms. Chevron assembled some 6000 feet of various types of booms in its initial preparations to combat the spread of oil once the fire on Platform C was extinguished, and constructed some 2000 additional feet of boom at the site.

During the period of this oil spill the booms were used in several ways with varying degrees of success:

a) to contain and guide the oil in the platform vicinity
b) to close off spaces between anchored barges (See section 7.3)
c) to corral and concentrate oil with skimmer boats (see Section 7.4)

Five types of booms were used by Chevron for spill control. Four were commercial products and one was fabricated locally from U. S. Navy designs. The commercial booms were:

a) The Kain Filtration Boom manufactured by Bennett International of British Columbia, Canada.
b) The T-T Boom made by Trygve Thune A.S. of Oslo, Norway and distributed by East Coast Services, Inc. of Braintree, Massachusetts.
c) The Slickbar Boom manufactured by Neirad Industries of Westport, Connecticut.
d) No. 1224 Spillguard Boom manufactured by Johns-Manville, New York, New York.

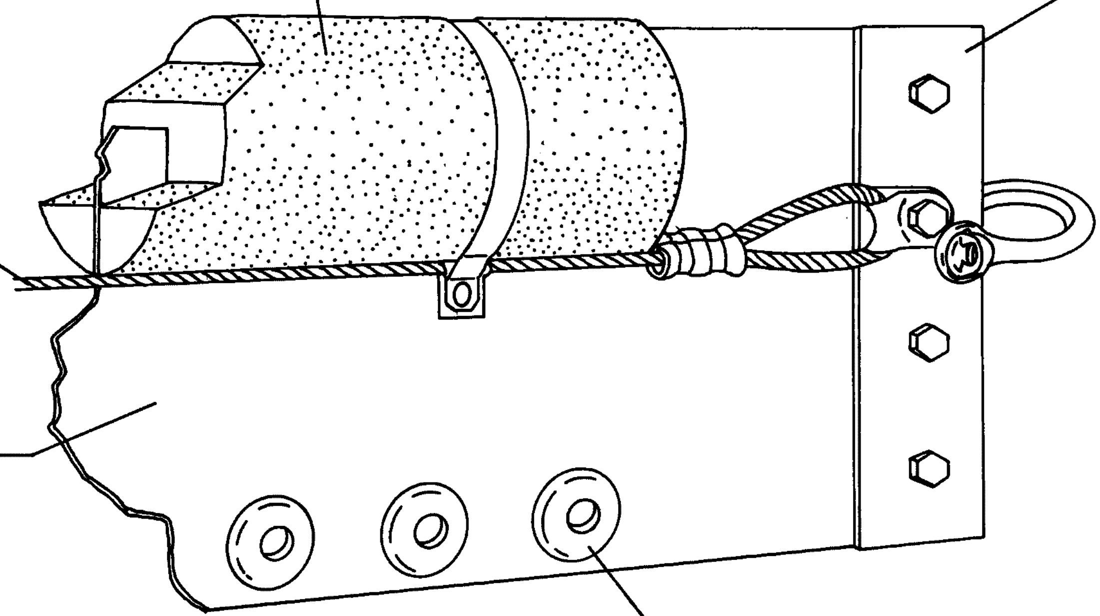
The "Navy Boom" was similar to a design fabricated at the Long Beach Naval Shipyard.

Two of these booms were of light construction and did not see use in open water as containment booms. These were the Slickbar and T-T booms. The Slickbar is essentially a plastic fin with a foamed plastic float on the upper edge, lead ballast at the lower edge and a 1/4" wire rope stress member, (Figure 4). The T-T boom is 3 feet high made of nylon reinforced PVC canvas. Foam floats attached to the skirt on 3'4" spacing, vertical aluminum rods, and lead on the bottom keep the canvas vertical. Two terylene lines serve as stress members. It normally floats with 2 feet submerged. These light construction booms were mobilized as a second line of defense to protect the oyster beds. Sections of T-T boom were also used on the skimmer boats to concentrate the oil slick for pick up (Figure 5).

Containment of the slick in open water required more substantial booms. The 1224 JM Spillguard boom is made of asbestos compound sheet with closed cell foam flotation. The sheet provides its own tensile strength and chain is strung along with lower edge to provide vertical stability. It floats with 12 inches above water and 24 inches below (Figure 6).

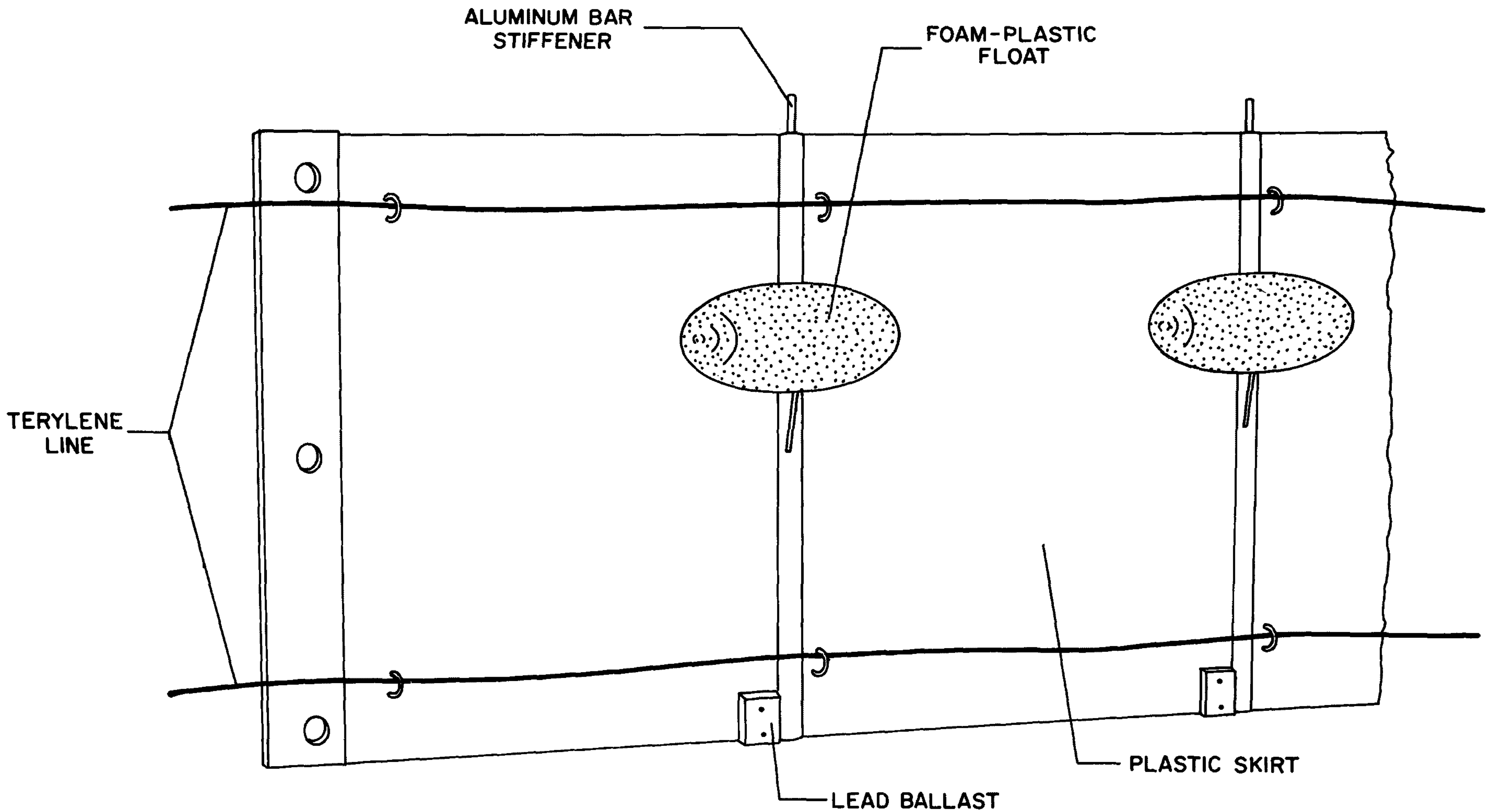
The Kain Filtration boom consists of a sandwich of wire rope net, chain link fence, and polypropylene filtration material. Detachable cylindrical floats cause it to float about 2/3 submerged. The filtration material is reportedly porous to water but opposes the passage of oil. The boom comes in three sizes, 3, 5, and 8 foot heights. The 8 ft. model was used by Chevron (Figure 7).

The "Navy" boom was fabricated in the field and consists of 4 x 8 sheets of 3/4 marine plywood, with the 4 ft. dimension vertical, supported by four (4) 55-gallon drums, two on each side. The 8 ft. sections were



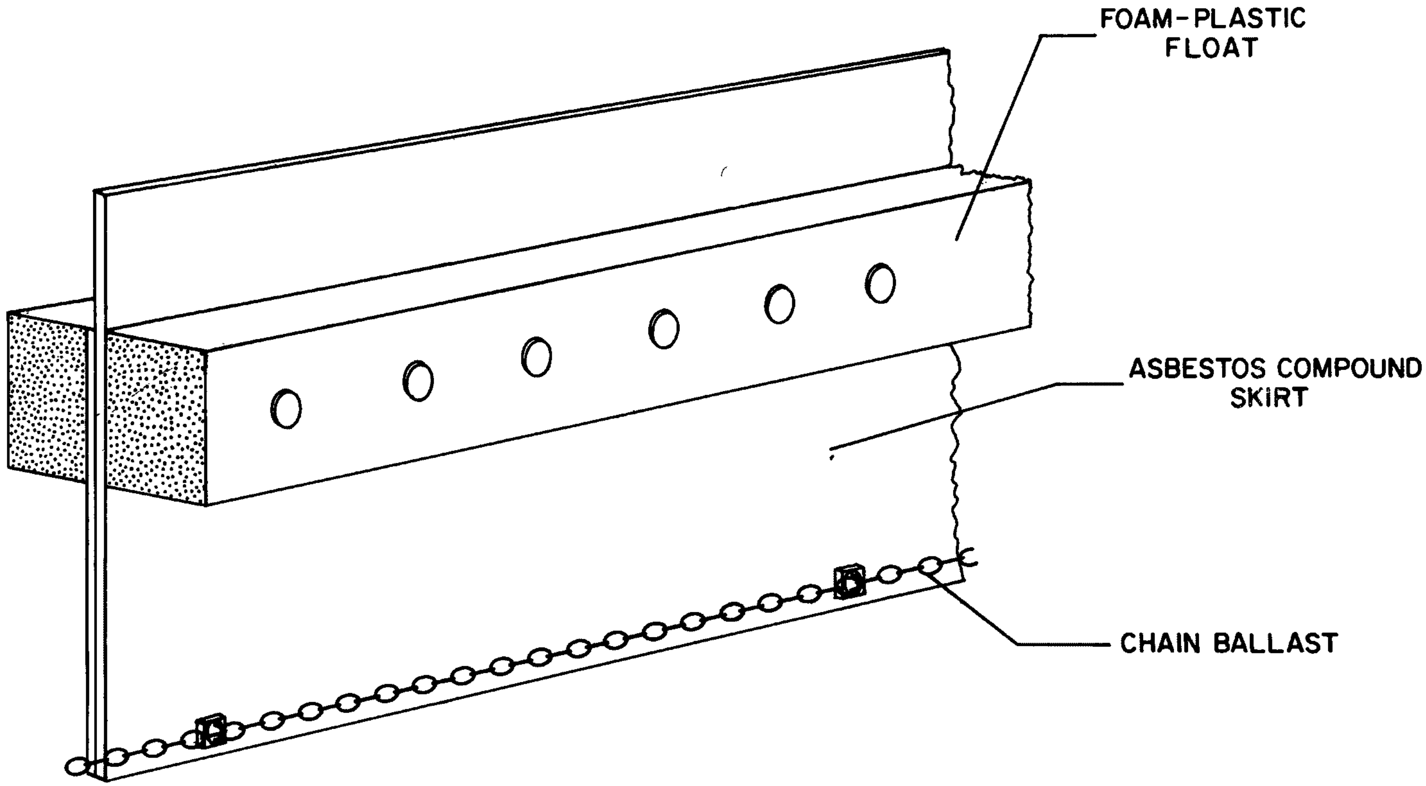
SLICKBAR BOOM

FIG. 4


ALUMINUM BAR STIFFENER
FOAM-PLASTIC FLOAT
TERYLENE LINE
PLASTIC SKIRT
LEAD BALLAST

T-T BOOM

FIG. 5



J-M SPILLGUARD BOOM

FIG. 6

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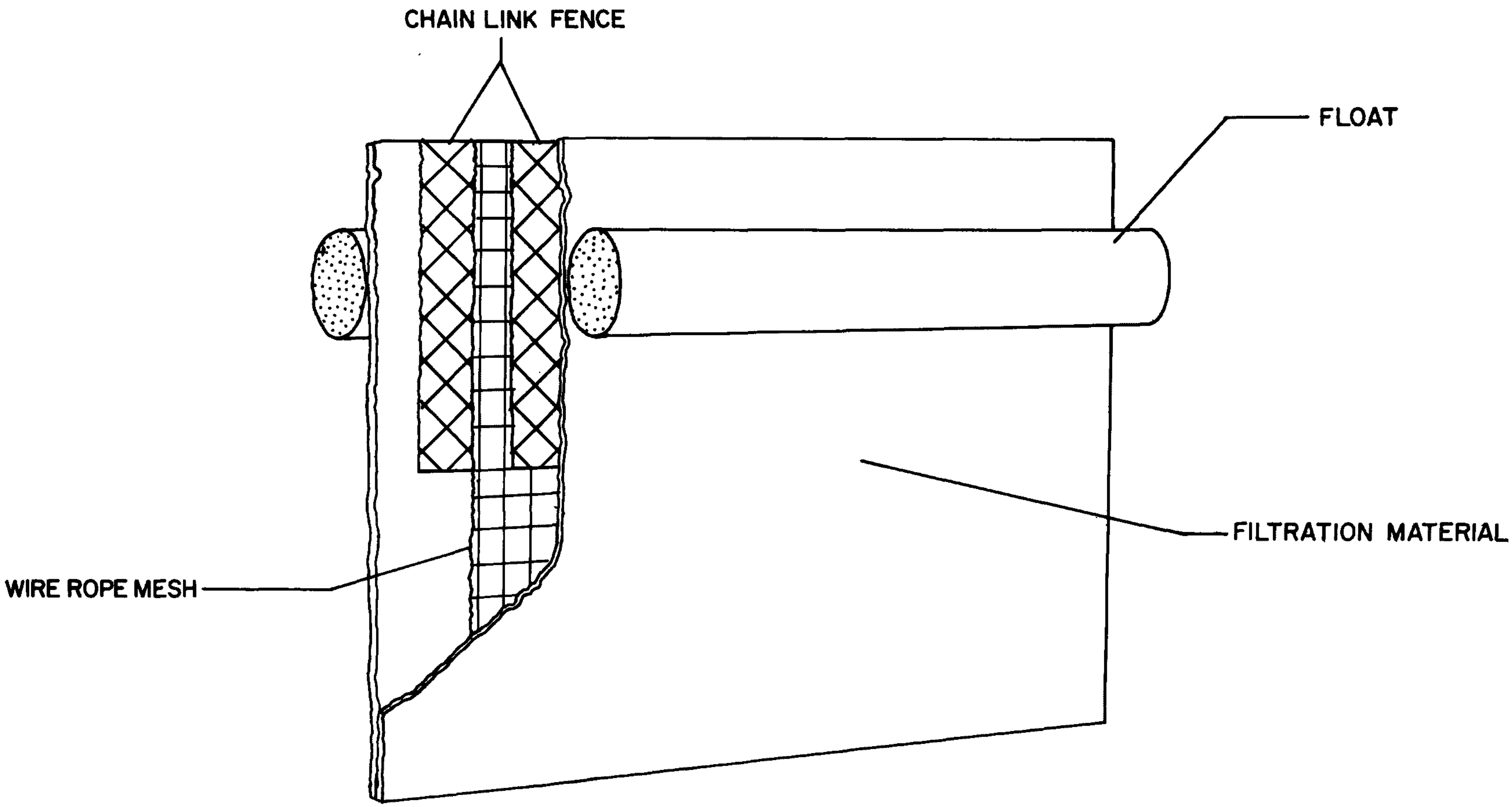
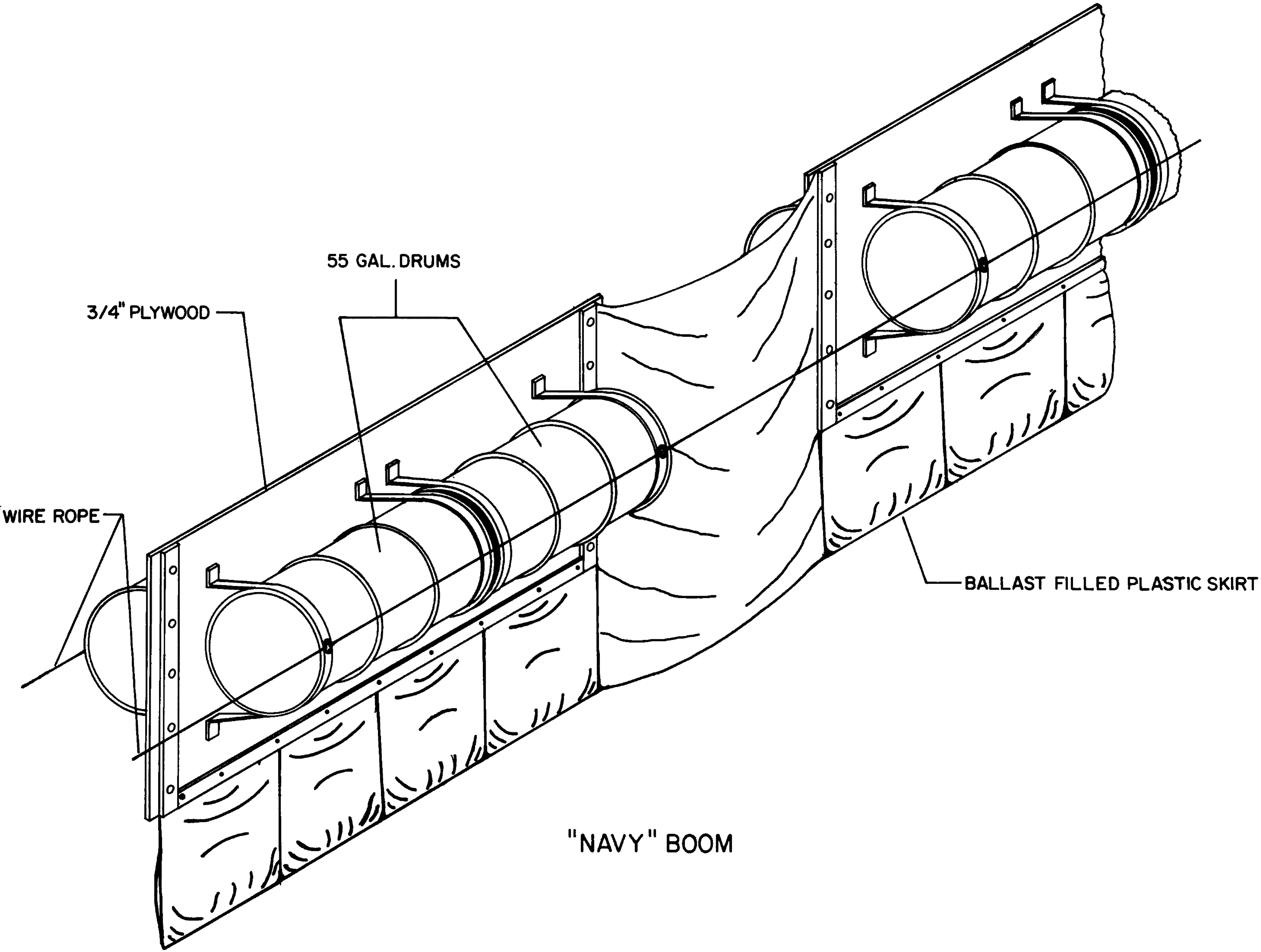


KAIN BOOM

FIG. 7



"NAVY" BOOM

FIG. 8

interconnected by sheets of 18 oz. Fasilon (Sun Chemical) canvas and a 3 ft. skirt of the same material weighted on the lower edge was attached to the bottom of the plywood. The sections were coupled by two lengths of 1/2 wire rope which carried the stress (Figure 8). The boom was fabricated and deployed inshore and then towed out on station.

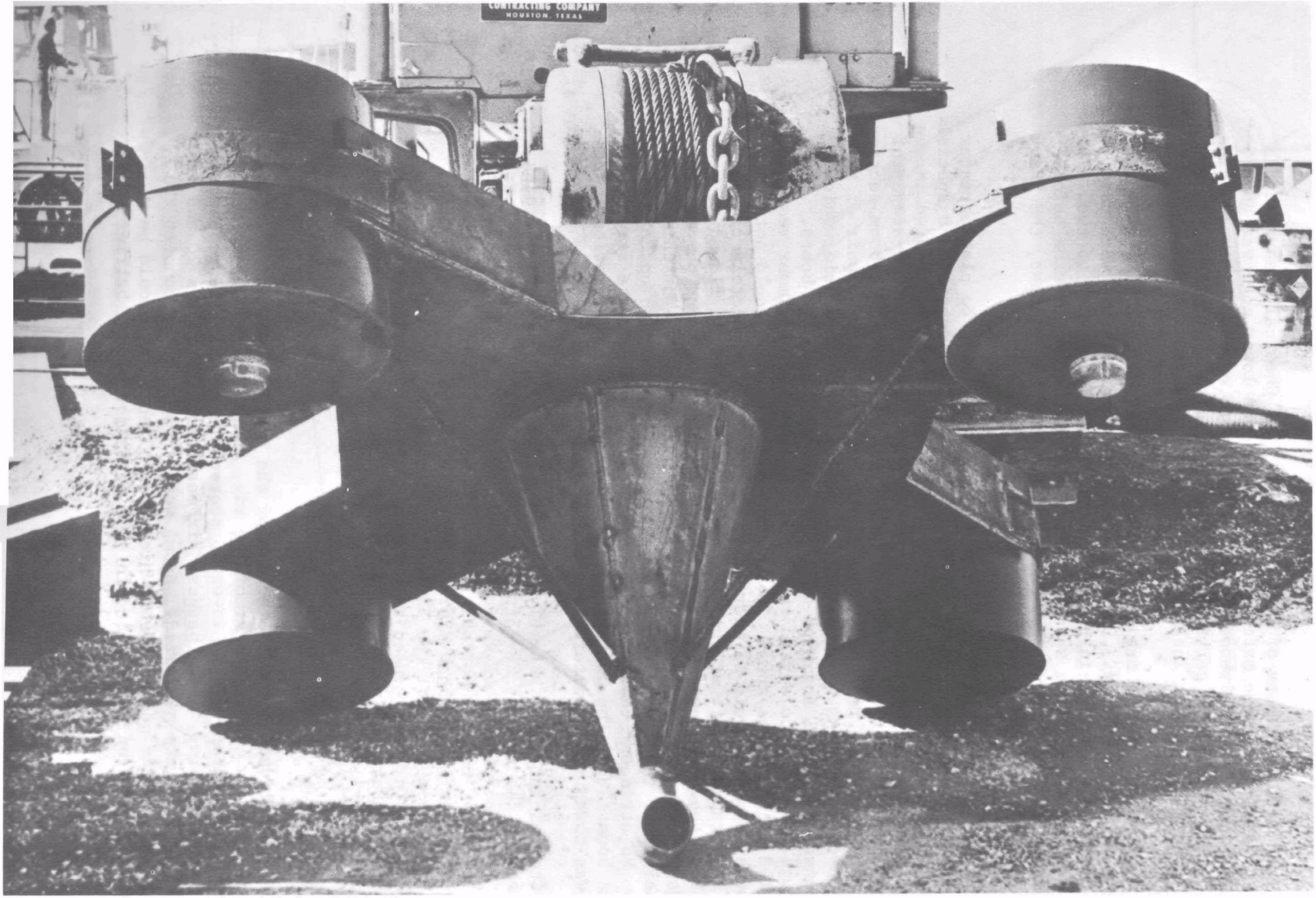
All the booms used were subject to severe attrition in the unprotected waters near the platform. Over the seven-week period they were used, this attrition resulted in the reduction of the boom types to two. The T-T boom was used on the skimmer boats for slick concentration before skimming. For major containment in relatively rough weather, the "Navy" boom was the only survivor.

The overall performance of the "Navy" boom led Chevron to place greater reliance on this type boom as time progressed. They outfitted a special barge for the mass production of boom sections and kept it moored in one of the sheltered bayous close to the platform. In the latter stages of the spill this was the only type of boom on the scene. The boom sections were not moored but remained mobile under the control of a pair of tugs. Two 500-foot sections were combined to make a V-shaped barrier which concentrated the oil for pick up by the skimmer barge and boats. The two tugs were used to apread the mouth of the V and a skimmer vessel held the lines to the apex. It was felt that the boom could not stand the strains which would be exerted if the apex was completely closed off, so a gap was left at the apex through which the oil flowed to be caught in the containment booms of the skimmer vessels and pumped aboard. In tests, oil would run under the boom if held in a V. For this type of operation, the "Navy" boom maintained its integrity in up to 6 foot seas. No stringent test was made to determine the ultimate strength of the boom. When the weather was too bad for pick up operations, the boom was towed into sheltered waters.

Once Chevron had their assembly line in production, they were turning out boom at the rate of 20-25ft./hr. at an estimated cost of $15 per foot. As a spill control device the "Navy" boom had the disadvantage that it is not readily portable and would take up quite a bit of storage space if it were held ready for immediate deployment. However, it would stack compactly if the 55 gallon drums were removed and stored separately. The fabric used by Chevron (Fasilon) was later deemed to be unsatisfactory for permanent or reusable booms since it could not be satisfactorily cleaned.

7.3 Barge Line

Priority was given to the protection of the oyster beds and shrimp nursery areas to the northwest of the rig, and a line of barges interconnected with booms was deployed to protect these valuable resources from possible harm. Seven barges, six measuring 250 x 70 x 20 and one 350 x 90 x 24, were mobilized. Booms were to be used to connect the barges and provide pockets from which the collected oil could be skimmed. The seven barges used in this operation made a barrier about



LINE OF CONTAINMENT BARGES PRIOR TO FIRE EXTINGUISHMENT

PHOTO COURTESY OF U.S.G.S.

Figure 9

2500 ft. long covering the NW quadrant at a distance of about 1500 ft. from the rig (Figure 9).

The effort to contain the oil spill met with varying degrees of success. The fixed barge system to the NW of the platform was only partially effective for 3 days of the 21 days it was deployed. At other times the wind/current pattern was driving the oil in another direction or the array was damaged due to adverse weather. Of necessity, the mooring lines on the side toward the rig were fairly short to assure that there was no chance of fouling the anchor lines from the derrick and jet barges. The commercial booms used to fill the gaps betoween barges were damaged whenever the barges dragged anchor and subjected them to any excessive strain. Originally three of the gaps between barges were filled with sections of Johns-Manville's boom and the other three with Kain boom. Because of its lighter construction, the Johns-Manville boom became damaged first with the Kain boom maintaining its integrity a little longer. The damaged sections were repaired or in the case of total destruction, were replaced with sections of the "Navy" boom. The barges which were initially positioned by March 4th required constant attention. On March 4th, one barge dragged anchor and holed another barge which had to be sent to Venice for repairs. It was returned on March 7th and the barges positioned with the sections of Kain and Johns-Manville booms in place. On March 8th, the weather made up from the NE with 6-8 foot seas. There was some dragging of anchors and damage to the booms.

The fire on the platform was extinguished at 11:29 a.m. on March 10th with a corresponding increase in the amount of oil which had to be contained. At this time, the wind was from the SSE and the slick was moving NNW toward the barge/boom array. Two sections of the array allowed oil to pass through and the skimmer barge along with a section of "Navy" boom was positioned behind the array to pick up and contain this oil. On March 11th, the weather picked up and the seas went to 3-4 feet. By late that day the booms between barges were inoperative and damaged. The "Navy" boom seemed to survive best.

On March 12th, the wind shifted into the north and drove the oil away from the barges, fortuitously allowing time to repair the booms. By March 15th the booms were again in position and holding back the oil as the wind shifted first to the south and later into the east. On March 16th, the winds picked up, resulting in 3-4 foot seas and the array could only hold back about 50% of the oil. A further deterioration of the weather on March 17th, with seas up to 12 feet as squall lines passed, damaged the barge/boom system to such an extent that it was returned to Venice. The whole concept of fixed booms was abandoned at this point. The array could have been re-established using heavier ground tackle but by this time enough experience had been obtained to make the decision that a mobile rather than fixed boom was a more practical way to combat this particular type of spill.

The fixed barge/boom array, once the initial bugs had been overcome, seemed to perform satisfactorily in 1-3 foot seas and held back most of the oil that it intercepted. Maintaining the integrity of the array became increasingly more difficult as the weather worsened. As the waves increased to 3-5 feet, it became only 50% effective and it became useless in anything above six feet.

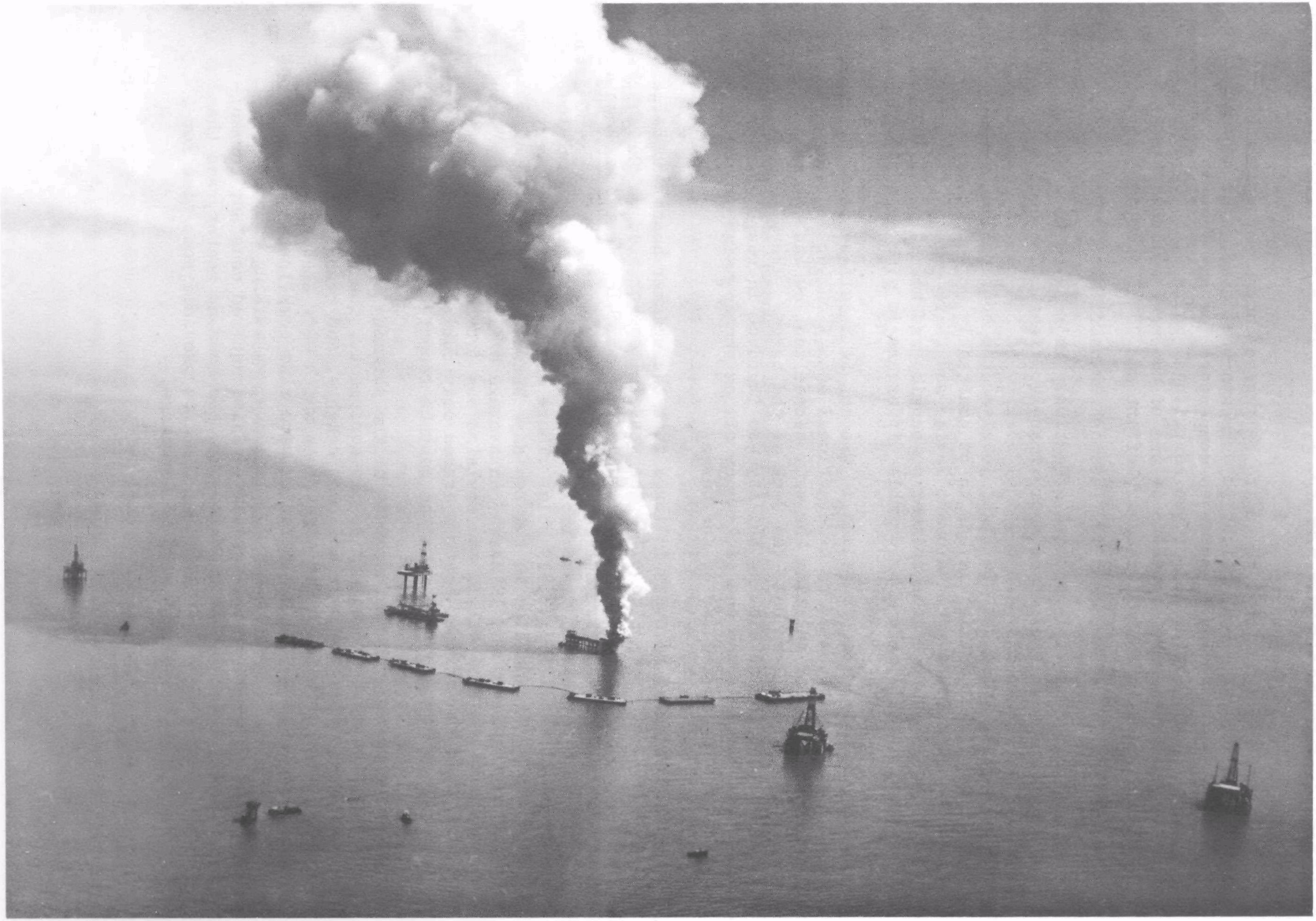
The array also contained none of the oil which drifted in any direction other than the NW quadrant. One of the peculiarities of this spill was the tendency of the crude which attained any great thickness to collect in narrow rows under the influence of the wind/current structure. There was, therefore, more to recommend the use of a mobile boom which could intercept these narrow plumes close to the platform than there was for a fixed position array. For the conditions existing in this area of the Gulf during the early spring, the moored barge/boom configuration was neither containment nor cost effective.

7.4 Recovery Equipment

The oil recovery system planned by Chevron was a three-pronged effort. Skimming was to be done in the boom pockets between the barges making up the NW protection screen. A 30 x 150 barge was also outfitted for skimming. This barge was rigged with a vertically adjustable collector weir extending along its 150 ft. dimension. This weir arrangement was not straight but shaped like the letter W. Oil entering the front was funnelled in and spilled over weirs into pockets at the back of each V segment. The oil-water mixture in the pocket was pumped to two decanting tanks with 1,000 barrel capacity. This barge was not self-propelled but was maneuvered by two tugs secured alongside on the 30-ft. sides of the barge. When conditions permitted, two 500 ft. sections of "Navy" boom were extended to each side and forward of the barge to funnel the oil to the skimmer barge. The forward edges of the boom sections were held in position by two more tugs. Coordination of positioning of the four tugs was done from a helicopter.

Six workboats were also outfitted for skimmer operation. Sections of T-T boom were extended out abeam of the boats with outriggers to form a semi-circular dam as the boat moved through the water. A skimmer-weir was suspended from a davit at the stern of the boat into the aft part of the semi-circle and the oil, water mixture was pumped into 100 bbl. separating tanks. The water could be drained overboard ahead of the outriggers so that any residual oil would be collected again. These six boats were mobile and designed as chase boats to pick up any oil which was not retrieved by the main boom or skimmer barge.

The skimmers used on the boom barges and skimmer chase boats were based on the Swiss skimmer design but were extensively modified and enlarged at the advice of William Altenburg of Altenburg, Kirk and Company, whom Chevron used as a technical consultant. The skimmers built consisted of four cylindrical flotation tanks which supported the four corners of a weir assembly (Figure 10). By adjusting the position of the floats with respect to the weir box, the thickness of the layer skimmed



ALTENBERG SKIMMER DETAIL

PHOTO COURTESY
CHEVRON OIL CO.

Figure 10

could be set. In order that the units be rugged enough for use in the open sea, no automatic weir height adjustments were used. The capacity of the pumps was made large enough to compensate for any loss of efficiency. They were diesel-driven centrifugal units with 400-600 g.p.m. ratings. These skimmers proved to be one of the most reliable pieces of equipment used in the oil recovery effort and 25 of them saw service at various times during the operation.

The skimmer barge was able to work effectively in seas up to 3 feet while the boats were limited to approximately 2 feet. The boat's capability was limited by the physical ability of the men to keep the over-the-side equipment at the right level as the boat rolled in the seas. The T-T boom outriggers had to be constantly worked to maintain the boom as an effective containment device and there were difficulties in making adjustments to the skimmer suspension and hoses. Individual boat skipper's skill made considerable difference in pick up efficiency.

The barge was more effective since it was not in itself subject to large induced motion. It ceased to be functional at oil collection when the ratio of oil to water entering the weir became too low and the seas began to splash the oil up onto the deck of the barge. There is some indication that the retrieving ability was improved in rough weather by turning the barge around and picking up oil on the downwind side with skimmers working in the lee of the barge.

Figures on estimated recovery indicate that the skimmer boats and barge did quite well at picking up oil. The vessels concentrated on the thick "rope" oil and, when weather conditions were favorable, seemed to keep up with the rate of spill. Chevron reports to the Coast Guard as reported in USCG Sitreps indicate representative daily rates of emulsion recovery of 2,367; 2,102; 2,819 bbls. There was a reported recovery of 15,623 bbls. of emulsion in the ten days between the time when the fire was extinguished and 19 March, an average of 1,562 bbls/day. Assuming that the percentage of oil in the emulsion was from 50 to 70%, and realizing that the skimmer boats operated only during daylight, the amount of recovery is commensurate with the amounts reported to have been spilled.

The evidence points out that success of the skimming operation was as much a function of the manpower as the equipment. The work on deck, priming pumps, adjusting weir and boom heights, and transferring oil to barges was all performed under conditions which were at best difficult and at times hazardous. The logistics were also complicated and required that the vessels be coordinated so that each was working to provide maximum effectiveness of oil recovery. This required constant communication between a surveillance helicopter, the command center, and the vessels. The delay in extinguishing the fire provided some time for training, and this time was used to advantage.

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8.0 SURVEILLANCE

8.1 Visual Surveillance

The FWQA and the USCG conducted routine visual observations of the spill from aircraft. Normally these aircraft flew twice per day. The purpose of these flights was the real-time determination of the status of the oil on water for the information on the Regional Response Team (RRT). An additional function of these flights was to inspect the islands, back bays and shorelines for evidence of oil on the beaches and for biological damage. No special navigational systems were used aboard these aircraft for precise location. Each flight resulted in a report; informal sketch maps of variable value were also prepared (1).

The USGS also made visual observations of the spill as part of its remote sensing program and produced a number of "maps" of the oil. These were not available to the RRT in near real-time, but will be used in a USGS report of the spill (2). Navigation for the USGS flights was performed with a mobile long range tracking radar based in Venice for the duration of this incident (3).

Chevron reportedly flew routine morning and evening flights using precise navigational control.

The groups above, as well as many State, Federal and other interested agencies and persons made numerous non-routine flights over the platform and spill area. Quite early in the casualty, the FAA, in cooperation with the USCG, restricted flights within a two mile radius of the platform to an altitude greater than 5,000 feet. This presumably was done to reduce air congestion for the protection of the operational people.

A normal observation flight would start at Charlie platform and follow the slick as far as possible; then circling the apparent end of the slick and back to the platform after which the shoreline, islands and bays would be examined. Generally only the most recent surface plume resulting from the existing wind direction would be readily detectable. It was often difficult to recognize the older slicks in the area which had "broken off" from the most recent plume due to wind or current shift.

Visual tracking of the older slicks was confused by a number of natural effects not connected to the spill. Some of these were:

a) Several zones of different water turbidity (color) the boundaries of which would migrate somewhat locally. One of these boundaries was just east of the platform during most of the spill incident.

b) In times of high winds the turbid water in the vicinity of the platform would form streaks not unsimilar to the oil dispersed locally in the water column. The streaking is caused by the breaking up of the thin surface layer of turbid fresh water which overlies the clearer

Gulf shelf waters.

c. Shoals can be seen through the water in some areas. There was little difficulty in following the new oil plume from Charlie platform outside the island chain and outside the "rip" at the edge of the delta, however, most observers commented on the profusion of what appeared to be chronic spills from operations in Breton Sound, in the bays and along the shores of the delta. Often, in trying to determine whether this oil could have come from MP41C, these slicks would be followed to other operations. However, a number of these in-shore slicks could not be readily traced to an operation by visual observations.

The above obviously poses a problem for the enforcement people, and could have far-reaching effects on litigation resulting from the spill. The question of whose oil did what, where and at what time, is not easily resolved in any area as heavily worked by different operators as the East Delta area. The photographs and records made by the remote sensing groups, as well as the maps made from controlled visual observations will certainly aid in an after-the-fact interpretation.

It was often difficult to follow the slick for more than several miles by boat without assistance from the air. The oil clean-up crews in the "chase boats" experienced similar problems. One technique for mapping the slick by boat is to make a series of low angle traverses or zig-zags across the slick, noting the edge on each traverse. Other methods are more time consuming and less certain.

8.2 Instrumented Surveillance

The number of groups participating in instrumented aerial surveillance was much smaller in this casualty than in the Santa Barbara incident (4).

The U. S. Geological Survey's remote sensing group in Phoenix had four aircraft operating out of the Lakeview Airport in New Orleans, and had a long range radar tracking van in Venice. They had the most sustained program.

The USCG arranged with NASA for overflights by one of their instrumented earth resources aircraft during the day and night of March 16, 1970. These flights were coordinated with simultaneous "ground truth" observations made by the LSU Coastal Studies Institute who were making other oceanographic observations in the area under contract to USCG.

The Remote Sensing, Inc. of Houston, a commercial organization, made a number of instrumented flights over several days. This was done on speculation that a market could be found for this service.

Numerous photographs of the spill were made from the aircraft making visual observations. The records and photographs produced in the programs listed were not available to the on-scene people in anything resembling "real time" and were, in fact, study programs with long term objectives, or documentation efforts. At this writing both the USCG and the USGS studies are still underway. The Remote Sensing, Inc. records and photos are presumably available for purchase.

8.2.1 U. S. Geological Survey Program (2) (3)

Equipment used:

Cessna 180 - Mod. K17 mapping camera - Hasselblad
Cessna 310 - Hasselblad, RV used
Beaver - HRB Singer imaging system, two channel: UV & infrared, Hasselblad - TV not used
H19 Helicopter - Low oblique photography
Mobile Radar Van - Modified surplus long range missile-tracking radar (M-33) with X-Y plotter readout, Van had direct communications with the aircraft.

After several days of test runs, the USGS having limited personnel, decided to concentrate their efforts on daylight color photography as they felt this gave them the best results. Kodak Aeroneg color reversal film was used.

Flights were made at least twice per day along the path of the oil slick. On days when the weather precluded color photography, visual observations were made. Flight altitudes were a nominal 10,000 feet, but varied according to weather conditions.

At this writing the photographs are being analyzed in detail by USGS personnel and the preparation of a study report is planned.

The color photographs are of excellent quality, showing considerable detail in water and water-oil characteristics, as well as the major operations on the water. Black and white mosaics made from the color photos lost considerable quality as many of the features with good color contrast had similar light densities. The slick can be seen in the B & W photos but much information is lost. Perhaps some of the benefits of color photography can be saved at a lower cost, by filtering and producing B & W prints at several different light frequency bands.

8.2.2 USCG Program

The USCG (5) arranged with NASA for a short series of flights over the spill area, coordinated with ground truth observations. The flights were made during the afternoon and evening of March 16, 1970.

Equipment (6) - An NP3A aircraft was used.

Data acquisition systems:

RC-8 metric camera - color 1R

RC-8 metric camera - color
KA 62 - multiband camera cluster - B&W/filtered to blue-green
RS-14 dual channel infrared scanner - 3.5 to 5.0 microns, and
8 to 14 microns
Scatterometer (13.35 GHz)
PRT 5 radiometer (8 to 14 microns)

At this writing the data is being analyzed by the USCG in Washington and a report of this study is planned.

All imagery is reported to be excellent, the color IR is considered to be the most useful, with the greatest number of observable features at high contrast. This includes those seen in normal color photography as well as additional temperature effects delineating some water boundaries.

The "UV" (blue-green) photos showed a much wider slick (thinner oil) than the IR scanner records, however, the IR records provide a greater number of features in both the water and oil.

No comments were made concerning the other data which is under analysis.

Flights were flown along the path of the oil slick, which on March 16, headed northwest from the platform past the islands and into Breton Sound.

8.2.3 Remote Sensing, Inc. Program (7)

Equipment: Aircraft - Fan jet Falcon, Cessna 337

Data Obtained:

Multispectral photography, B&W, B&W infrared, Color, Color IR, Infrared line scanner 1.3 to 5.5 microns - 8 to 14 microns, Microwave radiometer (13.7 GHz dual polarization)

Flight dates: March 11, 12, 14, 22, 25

Flight altitudes: 2,000; 10,000; 25,000 feet.

According to a company representative, all data was good quality. The most useful records were the infrared line scanner and the microwave radiation. The company clains to have modified their IR scanner equipment to provide better resolution than normally available (Figures 11 and 12). Flights were flown along oil slick paths.

The flights were made on speculation, however, at this time no buyer has materialized. The data is on hand at the Company office in Houston.

8.2.4 Evaluation

The major drawbacks to the use of aerial photography and remote sensing techniques are the time involved in getting the results to the people in the field. Much of the information gathered would have been of value to the pollution control operations, if it could have been made available in near-real-time to them.

When each of the remote sensing groups was interviewed, they were asked whether real-time transmission of the flight data to an oil operations center was within the state of the art today; each replied affirmatively. The photography could be duplicated and transmitted using TV techniques and the scanner data could be transmitted with conventional telemetry. Both would require advanced equipment. The USGS representative indicated that scanner data could be transmitted with their navigation link.

As utilized in this spill incident, the remote data was "For the Record" in the case of the USGS, for experimentation (USCG), and (Remote Sensing, Inc.) again for the record. When used for documentation, the data is not complete, as flights were generally restricted to the then-visible slick path and did not attempt to map the entire area (e.g., recording old slicks and chronic spills as well as the new surface plume).

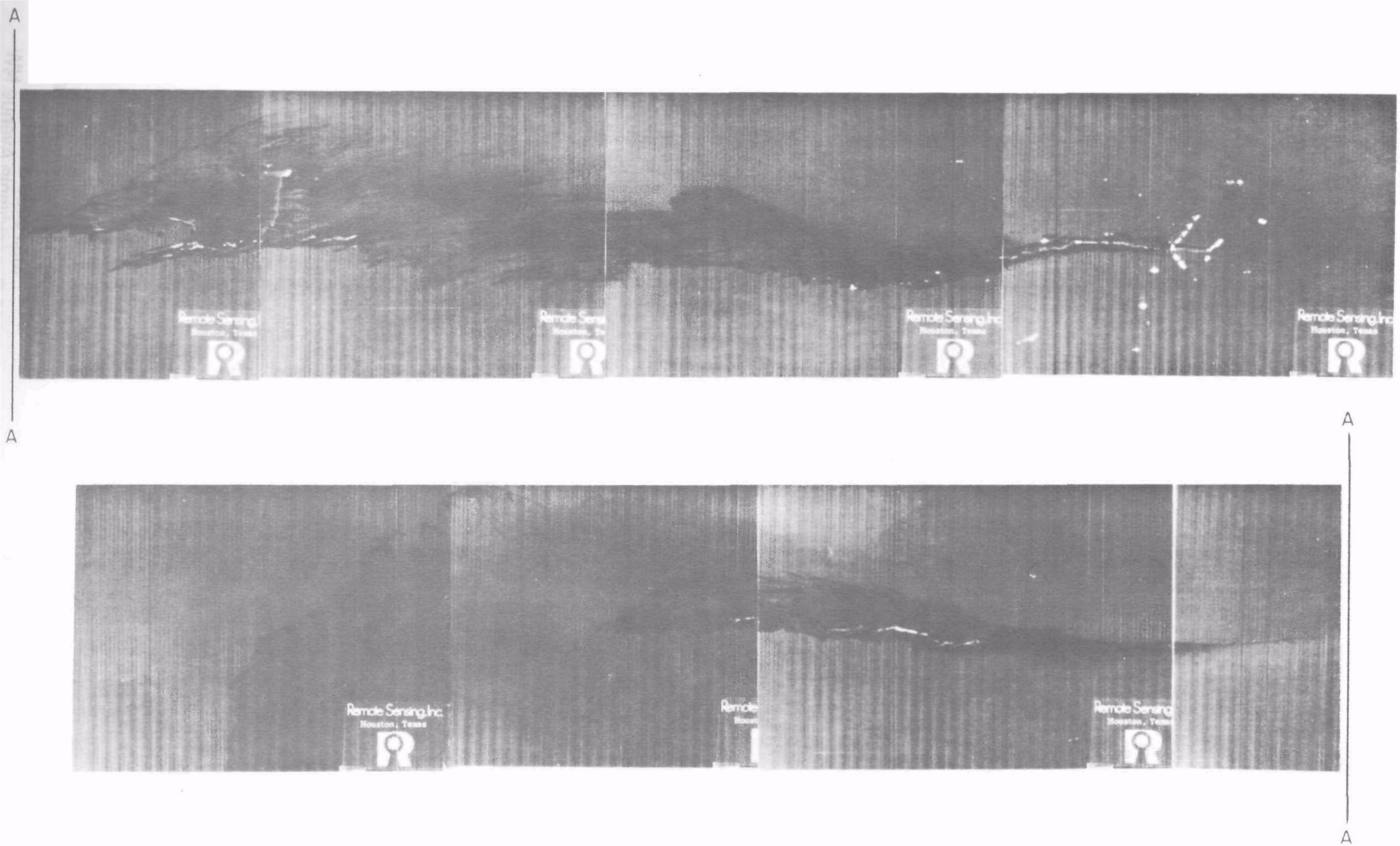

FIGURE II - INFRARED SCAN RECORD

8-14 MICRON RANGE — FLIGHT AT 10,000 FEET; 1:30 P.M., MARCH 11, 1970
PHOTO COURTESY REMOTE SENSING INC., HOUSTON, TEXAS.
BARGE LINE IS TO NW OF PLATFORM. OIL IS SEEN TO PENETRATE BARGE LINE.

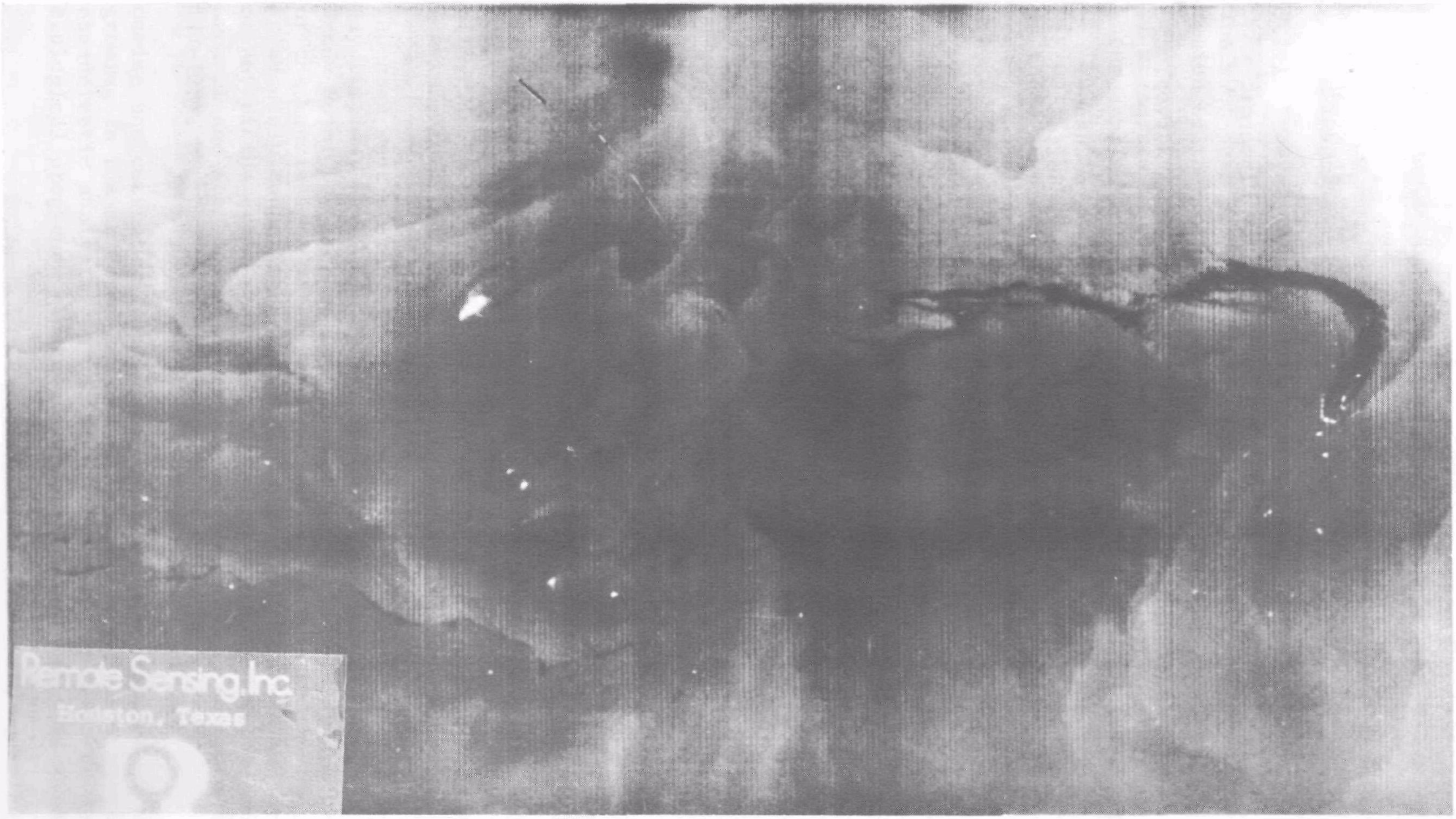

FIGURE 12 – INFRARED SCAN RECORD

8-14 MICRON RANGE — FLIGHT AT 35,000 FEET; 4:30 P.M., MARCH 11, 1970
PHOTO COURTESY REMOTE SENSING INC., HOUSTON, TEXAS.
WHITE MARKS IN LEFT CENTER OF PHOTO ARE GRAND GOSIER ISLANDS. OIL IS SEEN IN BRETON SOUND AND NEAR ISLANDS. WIND HAS SHIFTED BETWEEN 1:30 AND 4:30 P.M. AND IS BLOWING OIL EASTWARD. COOLER WATER PRESUMABLY FROM MAIN PASS IS SEEN BETWEEN PLATFORM AND ISLANDS.

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5. Personal Communication, Dr. Clarence Catoe, U. S. Coast Guard, Washington, D. C.

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7. Personal Communication, Dr. E. G. Wermund, Remote Sensing Inc., Houston, Texas

9.0 DAMAGE TO BIOLOGICAL RESOURCES

9.1 Biological Survellance and Sampling Programs Carried Out

9.1.1 Federal Water Quality Administration (FWQA)

The FWQA does not have any on-going biological sampling program in the region of the current oil spill. As a special project during this period, FWQA personnel took water samples at several levels on a number of transects of the area and one 360° survey around the rig (Figure 13). These samples were primarily taken for chemical analyses, but several of the water samples were delivered to Dr. Sam P. Meyers, a microbiologist at LSU, Baton Rouge. Dr. Meyers found that the oil contained in these samples apparently was serving as an energy source for numerous yeasts and bacteria present in the sample, and that the oil was in the process of natural degradation.(1)

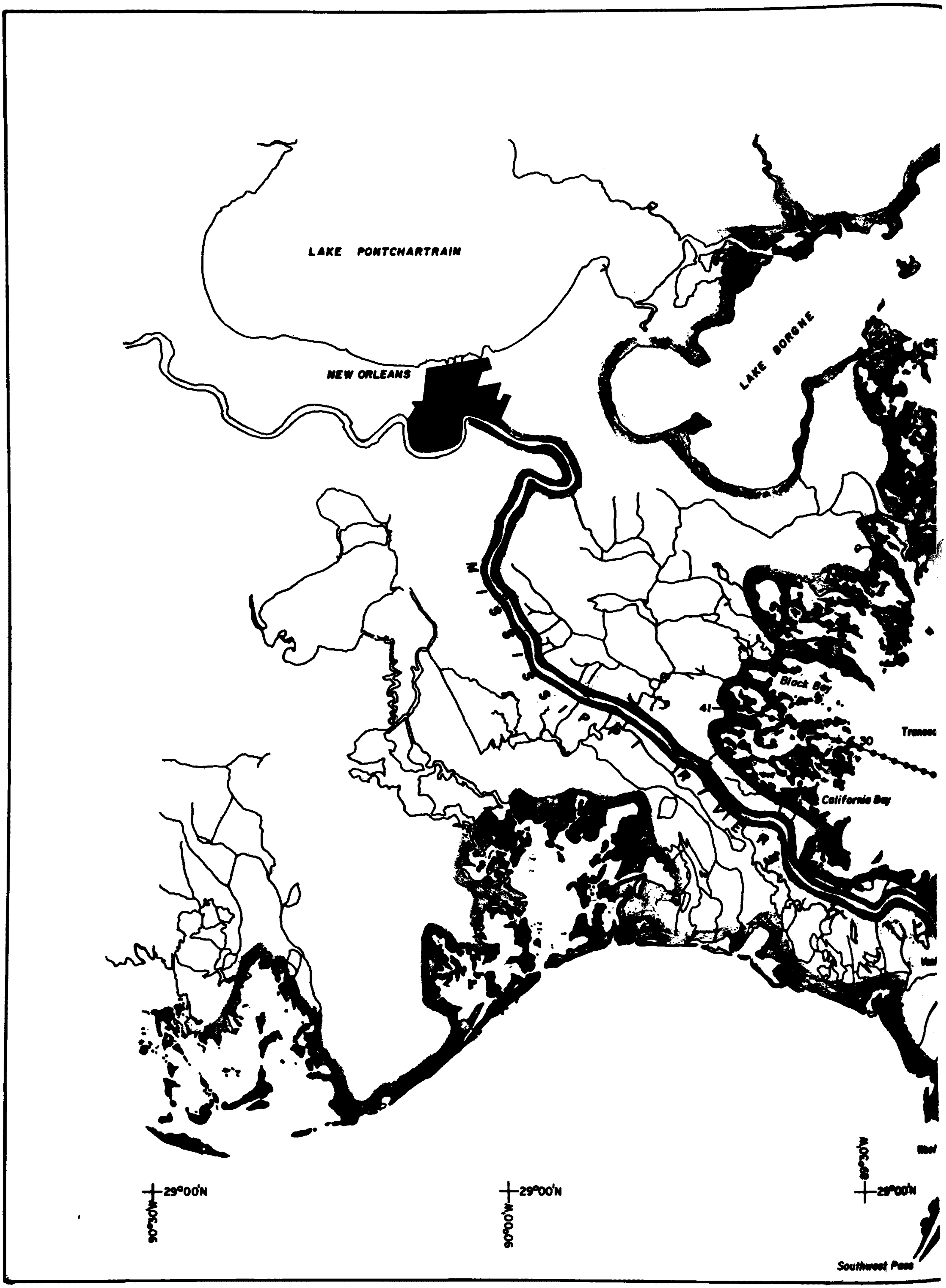
In addition to surveillance from boats, FWQA personnel made twice-daily overflights of the rig and surrounding areas to determine if extensive fish kill activity or harm to birds in the area had occurred. No fish or bird kills were reported during the period of the oil spill.

9.1.2 Louisiana Wildlife and Fisheries Commission (LWFC)

The Oysters, Water Bottoms and Seafoods Division of the LWFC maintains on-going biological surveillance in the area of the current oil spill. The area is designated Coastal Study Area II and is defined by Bayou Terre aux Boeufs on the northeast and by Grand Bayou on the west.(2). The area on the east side of the Mississippi River includes the following major water systems: Breton Sound, Black Bay, Bay Gardene, Little Lake, Bay Crabe, American, California Bay, Quarantine Bay and Grand Bay. Salinities range from medium to low in the upper marsh zone and from medium to high in the lower part of this area. Much oil activity is found in and around Breton Sound and adjoining bays with many pipelines, oil wells, platforms, storage tanks and access canals located in this general area.

The area west of the river includes the following major bays: Bay Adams, Bay Bastian, Bay Pomme d'Orr, Scofield Bay, Bay Jacques, Skipjack Bay, Sandy Point Bay and Bay Lanaux. This area is nearest in the westward sweep of the Mississippi River, and retains salinities in the medium ranges. It possibly ranks highest in the production of fishes and crustaceans of any of the areas along the Louisiana Coast. A description of Coastal Area II and its biological resources can be found in Appendix C (pages 127-128).

During the current oil spill this Division took samples of oysters growing in the affected area on several occasions, for special organoleptic analysis, in addition to continuing their on-going biological programs. There was no evidence of oil contamination


LAKE PONTCHARTRAIN
NEW ORLEANS
LAKE BORGNE
MISSISSIPPI RIVER
Black Bay
41
30
California Bay
Southwest Pass
29°00'N
90°30'W
29°00'N
90°00'W
29°00'N
89°30'W

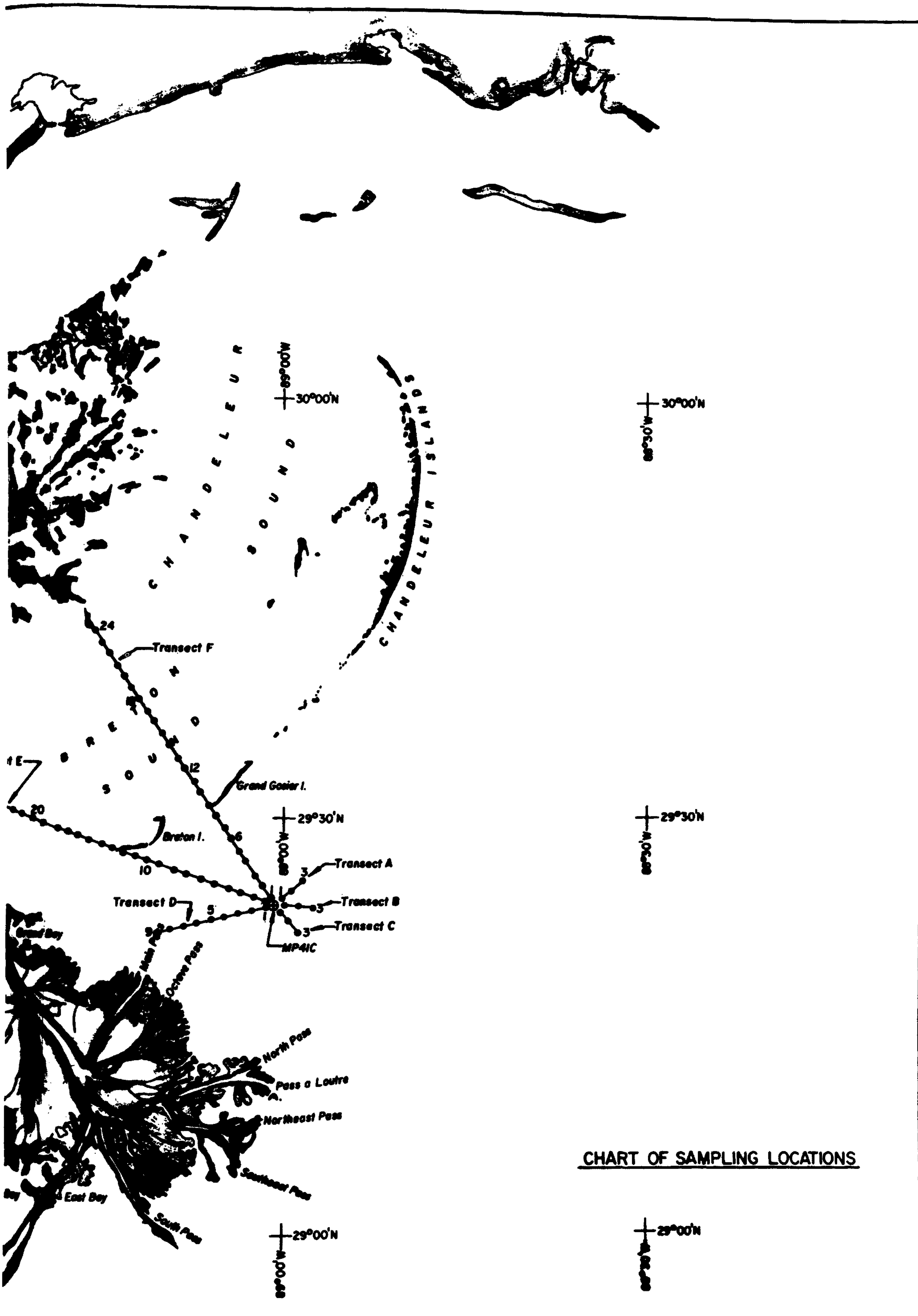


CHART OF SAMPLING LOCATIONS

FIG. 13

reported in the special samples taken.

The Water Pollution Control Division of the LWFC maintains on-going surveillance of streams and river channels in the delta region for the presence of oil and other pollutants.

9.1.3 Chevron Oil Company

The Chevron Oil Company has contracted with local ecologists to undertake an extensive field biological survey program. This program was undertaken during the last days of the uncontrolled oil spillage, and the results have not been made available at this time. Prior to this program, Dr. John G. Macking, a marine biologist from Texas A & M University, visited the area on February 22, 1970 at the invitation of the Chevron Company.

9.1.4 Louisiana State Department of Health, Bureau of Environmental Health

The Bureau of Environmental Health maintains an on-going program responsible for determining water quality in terms of toxicological and parisitological parameters of public health importance related to the Louisiana shellfish industry.

9.1.5 U. S. Bureau of Commercial Fisheries

The Bureau of Commercial Fisheries office in New Orleans, Louisiana maintains statistical data on Louisiana seafood catches. This is an on-going program which obtains records from processors.

9.1.6 Department of Food Science, Louisiana State University

The Department of Food Science and Technology, LSU, maintains an on-going program, in conjunction with other state agencies, to assess the organoleptic quality of Louisiana oysters and shrimp.

9.2 Hazard Potential of Oil Spills on the Biological Resources of the Area

The biological hazards of oil in the marine and estuarine environments have been considered in great detail (3 through 6) and the general conclusion reached is that oil spilled in the open sea does not constitute as severe a hazard as it does in a confined shallow bay or estuarine marsh. In shallow bays and estuaries such as the Breton Sound area, evidence exists that fish and shellfish might suffer varying degrees of harm in the event that oil did penetrate and persist in the environment even for short periods of time (5).

The chemical emulsifiers have been shown to have varying degrees of toxicity to selected organisms in acute bioassay tests. Chemically dispersed oil has been shown to be much more toxic to selected organisms than either the oil or the chemical dispersant (7). There would certainly be detrimental effects, at least in some organisms, in the event that these chemicals and the dispersed oil reached their biologically critical levels as a function of application time and concentration. The acute toxic manifestations might be lethal or sub-lethal depending both on the organisms involved and other prevailing environmental parameters.

The effects of chemically dispersed oil on the dissolved oxygen content of a water body must also be considered, as both the oil and the dispersant may represent a significant BOD load (8). Reduced oxygen levels could present a hazard to organisms in this water body, with low mobility if mixing and dispersion are low.

What has not been fully investigated is the problem of chronic applications of these materials in the biosphere and their subsequent effect on the total ecology. Another area little understood at present is the potential for insidious long term effects on the biosphere due to short term sublethal intoxications. Both of these deserve more attention since the application of these chemical dispersants is being recommended by their manufacturers for both exceptional and chronic oil spills, the first instance represented by a major spill as considered in this report and the second by the chronic spills which occur daily at functioning rigs in the form of oily water wastes.

9.3 Ecological Considerations

The relationship of offshore oil development to specific ecological changes is difficult, if not impossible, to support technically at this time. Yet, in the past decade, coupled with an explosive development of the offshore oil industry and subsequent increase in chronic oil pollution in the Louisiana area there have also been extensive ecological upheavals. Some of these, such as the changes in mammalian populations, have been due at least in part to introduction of new species and natural disasters. Other instances, like the decrease in the production of the 1964-65 shrimp year classes despite increased postlarvae reaching the nursery grounds; shrimp kills in cultivated ponds in 1967 associated with fish kills in the area; disappearance of the brown Pelican, and several years of poor manhaden catches after reported fish kills in 1964-65 are suggestive of some environmental imbalance. Finally, conditions associated with oyster-grass die-off suggest that pollution may be a direct factor (See Appendix C, pages 127 to 128).

9.4 Fate of the Spilled Oil

Reports of the increased frequency of observation of petroleum lumps on the surface of the sea suggest that at least some of the heavier oil fractions may persist for a considerable time. In studies made in the eastern North Atlantic Ocean and the Mediterranean Sea, petroleum lumps of minimum age estimated from weeks to months were found (9). The age data was obtained from chemical analyses of the lighter petroleum fractions present in the lumps, and also from biological data related to the flora and fauna growing on the lumps. No quantitative technique was available to estimate the maximum age of these lumps.

In a recent work (10) oil is shown to persist in the sediments of Buzzards Bay to the detriment of the indigenous biota. Oil in the sediment is characteristic of areas of chronic oil pollution.

However, other field observations indicate that the major portion of polluting oil does not persist very long in marine environments in and around the Breton Sound area, nor in the open oceans of the world (11, 12). Reduction in oil is attributed to the evaporation of the more volatile fractions, and to the abundance of biochemical activities of a large variety of oil-oxidizing micro-organisms which are in highest concentration in areas of chronic oil spills (13). In laboratory tests using 15 different crude oil samples from Louisiana wells, it has been observed that all of these samples were susceptible to bacterial oxidation and were more than 50% oxidized after 28 day at 25° C. From 50-100% of the oil was eventually oxidized to CO_2 and water (13). Oxygen does not seem to be the limiting factor in the rate of oil oxidation. It appears that the levels of mineral constituents in the environment are most important (13). In addition to oxidizing the oil present in the sea, bacteria and other micro-organisms increase in numbers and thus a portion of the energy of the oil is passed up the food chain to protozoans and other marine life (14). There is a possibility that certain toxic or carcinogenic hydrocarbons are also passed up the food chain.

Recent work indicates that increased bacterial growth and the decomposition of oil into products exhibiting no toxicity occurs within 48 hours (14). Yet another study shows that oil incubated with bacteria under both aerobic and anaerobic conditions produced products more toxic than the original oil (15). While this last study implies that the increased toxicity is due to decomposition products of the oil, no control samples were run to eliminate the possibility that organisms producing endogenous toxins, proliferated in the media.

The apparent discrepancies in the two studies cited above are probably due to a large number of possible variables. A few of the most important are: type of oil, types of decomposition and test organisms, fresh or salt water, among others.

9.5 Potential for Ecological Upset and Public Health Hazard

The toxic dinoflagellate, *Gymnodinium brevis* and others (6), are known to exist in the area of the spill, and can cause human intoxication when oysters, made toxic by feeding on these organisms are subsequently consumed. In addition, toxic dinoflagellates are known to produce extensive fish kills.

A potential energy contribution of the oil serving as an organic nutrient (13, 14) during the current spill, coupled by the wells' close proximity to the inorganic nutrient laden Mississippi waters are unique factors which could contribute to the explosive growth of a toxic marine organism with resultant red tides, fish kills and possible human intoxication.

In addition to the current oil spill being considered, the many thousands of producing wells in the area issuing small chronic spills may cause a continuous problem of this nature. It has been estimated that a typical offshore well has an effluent rate of 2,500 barrels of oily water per day. With oil present at about 1,000 ppm, this represents 2.5 barrels of oil per day from each well. In short, the problem of oil pollution from offshore wells is not only one of spillage but also one of the cumulative effects of a continuous discharge of oily water effluent.

Oil pollution in Louisiana may play a major role in the energy relationships in the area and constitute both an enrichment and a potential danger.

9.6 Assessment of Damage to Biological Resources in the Breton Sound Area Due to the Current Oil Spill at Chevron MP41C Platform

From reported gross observations and data gathered by local and federal agencies, it would appear that there was little or no evidence of any acute biological problems that were precipitated by the current oil spill. What is still to be determined, however, are the possible long-term effects of acute exposure to the polluting oil and chemical residues in the area.

However, there are several factors associated with the current oil spill which mitigate against the findings of any substantial biological damage. These are comprised of both physical and biological events.

First, the effect of spring flood stage, coupled with favorable currents and winds in the area of the spill apparently did not allow substantial amounts of oil or chemicals to reach the biologically productive back bay and delta areas. Secondly, timely biological phenomena limited unfavorable effects. Major bird migrations had already been completed, leaving a reduced resident bird population; oysters and crabs had not yet spawned; and adult menhaden had not yet entered the vicinity for spring feeding. The spill did, however, coincide with the peak time of arrival of postlarval shrimp migrating into the marsh areas.

Other factors limiting the unfavorable effects of the current spill included the fact that the commercial menhaden and inshore shrimp seasons had not yet started. If these were in progress, regardless of the lack of toxicological effects on these species, there is the very strong likelihood that the fishermen's gear would have been fouled by the spilled oil resulting in economic hardships, and inability to harvest the biological resource. The tainting of seafood with an oil taste, whether real or imagined has a detrimental market effect, during and some time after a large spill.

The potential public health hazards due to enrichment of the environment with oil represents an area that has not been fully considered in the current oil pollution literature. It would appear that in inshore areas there could be a significant local enrichment leading to blooms of noxious organisms that might result in fish kills and food poisoning. At the same time, since organisms vary in their sensitivity to oil, important food organisms in the food web might be inhibited, causing ecological repercussions, and further compounding the effect of noxious organisms' blooms. In this case, it should be made clear that direct toxicity of the oil or chemicals used for dispersion are not considered to be the important toxic factors, and yet the final outcome could produce environmental and public health hazards of major importance.

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10.0 ACKNOWLEDGMENTS

The principal sources of information were:

Federal Agencies

The Federal Water Quality Administration
The U. S. Geological Survey
The U. S. Coast Guard
The Bureau of Commercial Fisheries
The U. S. Weather Bureau
The U. S. Army Corps of Engineers

State of Louisiana Agencies

Wildlife & Fisheries Commission
Department of Conservation
Department of Health

Universities

Louisiana State University (LSU)
Tulane University

Commercial

The Chevron Oil Company
Remote Sensing, Inc.

Publications

Numerous technical publications and newspaper articles individually cited in section references. Mr. John Nordell of the New Orleans Time-Picayune Library was most helpful.

Special recognition is given to Mr. Jerry T. Thornhill and Mr. Charles Gazda of FWQA, who gave invaluable assistance and cooperation to The Documentation Team on the scene, and to Mr. George Putnicki, Project Officer, FWQA, who provided important guidance. Dr. Thomas Murphy of FWQA provided much early information and guidance which permitted the team to rapidly enter into effective field operations. He also provided valuable critical comments on the draft of this report.

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Mr. George Putnicki, Director, Research, Development and Administration, South Central Region, FWQA, Dallas, Texas

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Mr. Skibitzke, U. S. Geological Survey, Phoenix, Arizona

Dr. A. E. Smalley, Department of Biology, Tulane University, New Orleans, Louisiana

Mr. George Snow, Bureau of Commercial Fisheries, New Orleans, Louisiana

Mr. Jerry T. Thornhill, Contingency Plan Officer, FWQA, Dallas, Texas

Dr. E. G. Wermund, Remote Sensing, Inc., Houston, Texas

Mr. Curtiss Wright, Johns-Manville Inc., New York, N. Y.

APPENDIX A - OCEANOGRAPHY OF THE EAST DELTA AREA

The Chevron MP41C platform (Fig. A.1) is oceanographically located in a transition zone between the fresh turbid Mississippi River water and the salt waters of the Gulf of Mexico. Water currents here are formed and influenced by a complex interaction of a large number of variables of river stage, wind direction, tides and general oceanic circulation.

Two major works (1), (2), describe most of the current knowledge of the area's oceanography and this section is drawn in good part from them.

The Coastal Studies Institute of LSU had a graduate student working in the passes of the East Delta at the time of the spill, and extended their coastal studies (supported by ONR) to the spill site under contract to USCG. This group performed their work from a USCG cutter and helicopter on an "as available" basis.

Measurements were made of:

a - Surface, mid-water and bottom currents
b - Salinities and temperatures
c - Tides and waves
d - Some aerial infrared and color photographs

On March 16, this group performed "ground truth" observations in coordination with USCG - NASA remote sensing flights (see Sect. 8.0) (3).

The observations and conclusions of the L. S. U. study are similar to those formed by the documentation group. (4)

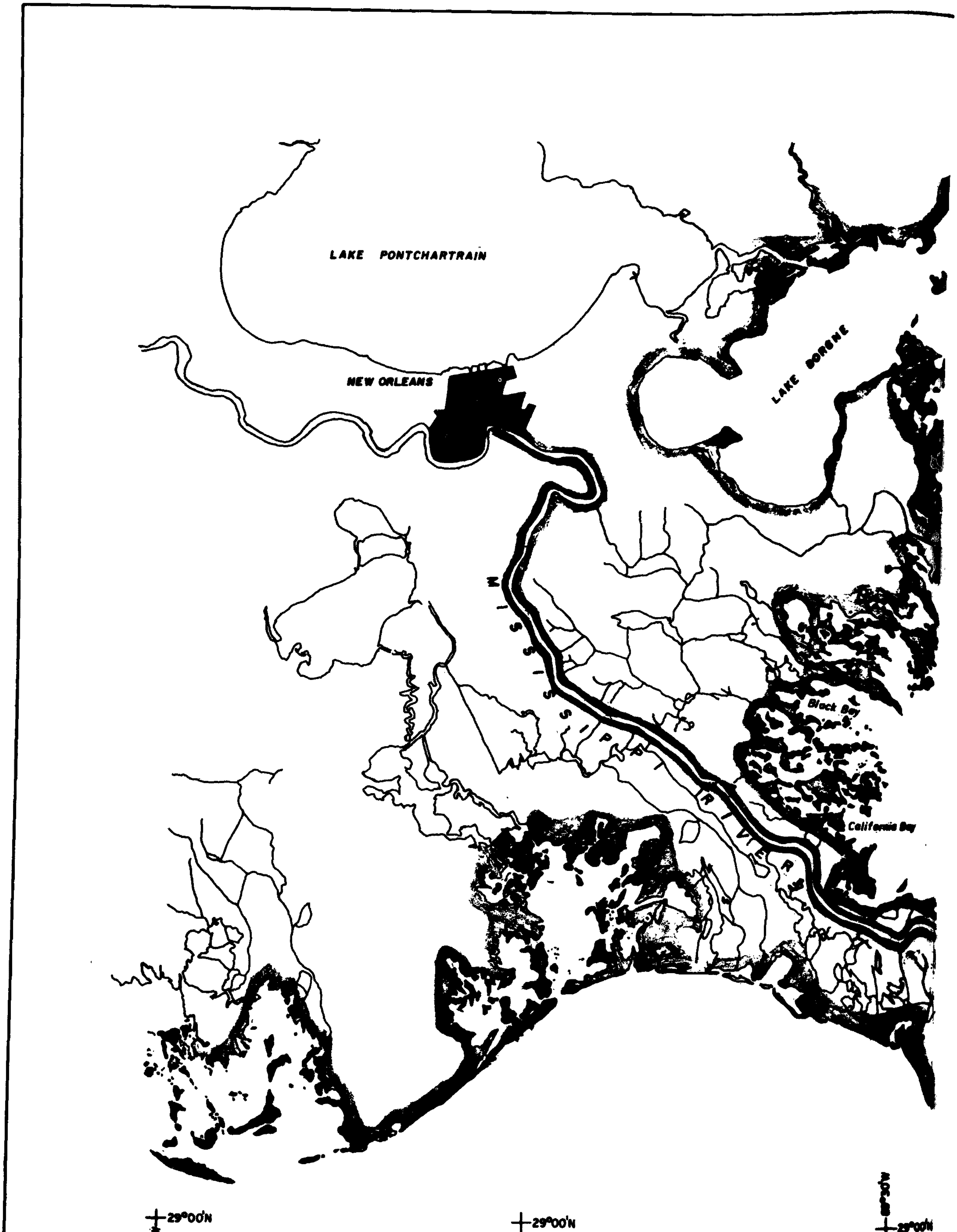
The following description of the circulation east of the Mississippi Delta is adapted mainly from the excellent, comprehensive work by P. C. Scruton (1) to which the reader is referred for a far more detailed treatment.

The circulation in the region east of the Mississippi Delta is typical of that in areas where a continuous supply of fresh water is being mixed with salt water, and has the following characteristics:

a) It is a two layered regime superposed on tidal oscillations and wind currents. The average surface current flows seaward, and the average deep current flows landward. This is caused by hydraulic head and density differences.

b) There is a seaward increase of surface salinity and a landward decrease of bottom-water salinity.

c) There is a net transport of fresh water seaward in the surface layers, and a net transport of salt water in the opposite direction in the deep layers. Salt exchange between these two layers takes place by turbulent


LAKE PONTCHARTRAIN
NEW ORLEANS
LAKE BORGNE
MISSISSIPPI RIVER
Black Bay
California Bay
29°00'N
90°30'W
29°00'N
90°00'W
89°30'W
29°00'N

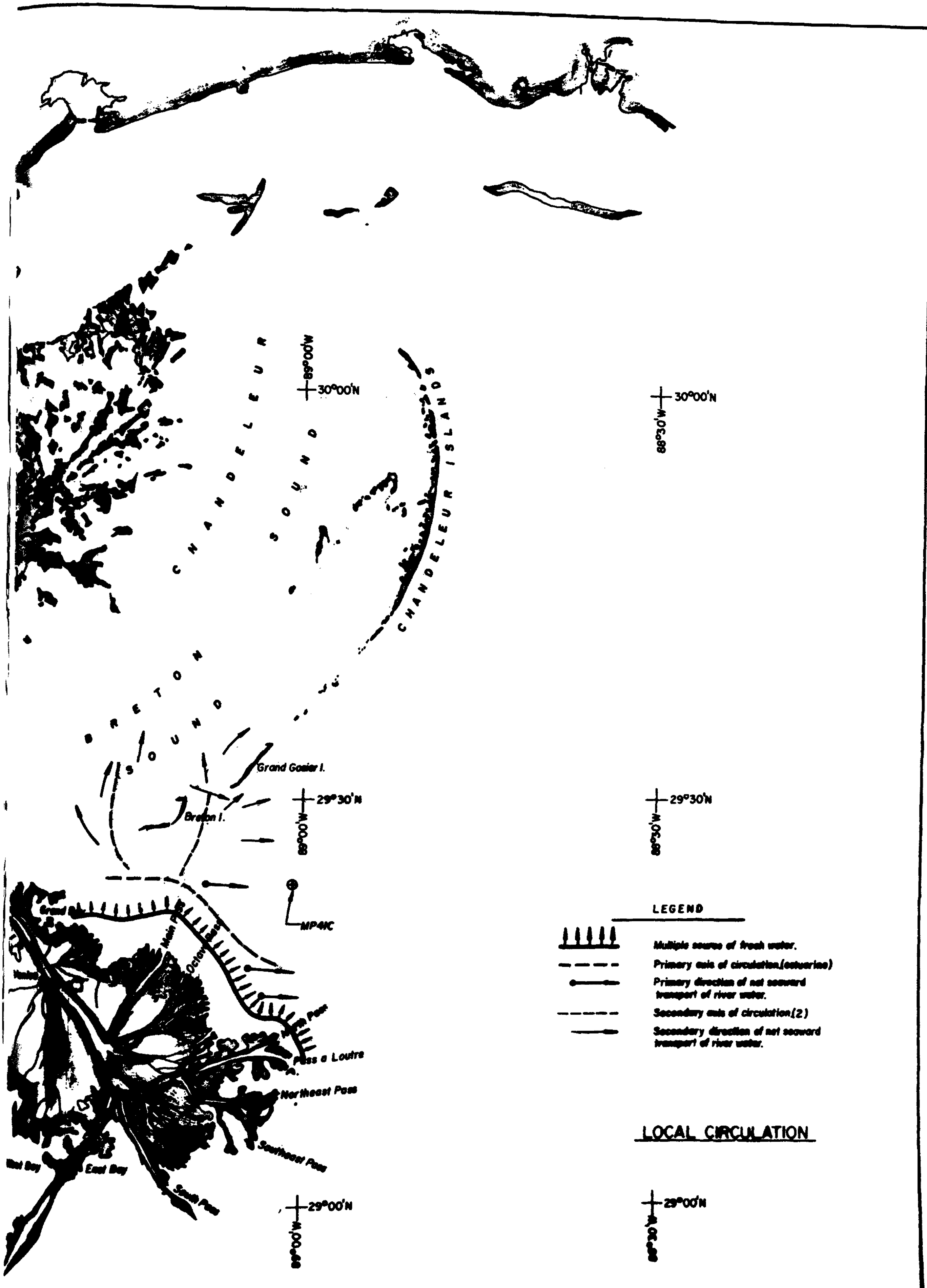

CHANDELEUR SOUND
CHANDELEUR ISLANDS
BRETON SOUND
Grand Gosier I.
Breton I.
MP41C
Pass a Loutre
Northeast Pass
Southeast Pass
South Pass
East Bay
30°00'N
29°30'N
29°00'N
89°00'W
88°30'W
LEGEND
Multiple source of fresh water.
Primary axis of circulation (estuarine)
Primary direction of net seaward transport of river water.
Secondary axis of circulation (2)
Secondary direction of net seaward transport of river water.
LOCAL CIRCULATION

FIG. 14

diffusion and vertical flow of salt water.

d) Bottom salinity at any point varies with the tide - increasing on the flood and decreasing on the ebb.

e) The vertical salinity gradient depends on the river discharge and on the wind speed. This type of circulation pattern is called estuarine because it was first described for estuaries. An estuary is defined as: "...a semi-enclosed coastal body of water having a free connection with the sea, and within which the sea water is measurably diluted with fresh water." (5) In most estuaries there is a single major fresh water input (e. g. The Potomac River into Chesapeake Bay) however, in this area, fresh water is supplied to the system from many outlets of the Mississippi on the east shore of the delta. Because of this continuous supply of fresh water, there must be a continuous seaward distribution. Fig. 14 shows the principal features of the circulation east of the Mississippi Delta. The primary axis of circulation parallels the delta shores, and the primary direction of net seaward transport is eastward. There are also indirect, secondary connections with the gulf northward through Breton and Chandeleur Sounds, and just south of Gosier Island. Since the primary axis is the shortest and most direct route to the open gulf, since it is relatively wide and deep, and since it is the locus of the main tidal currents, it probably transports some fresh water seaward at all times. The secondary axes never transport the volume that the primary axis does. These are most active in the presence of easterly and southerly winds, and are inactive in the presence of northerly winds. The secondary axis west of Breton Island is favored by large tidal ranges, that to the east by low tidal ranges.

According to Walsh (2) the following factors influence, in varying degrees, both the short and long term variations in the river outflow pattern:

1. River discharge
2. Local wind field
3. Littoral currents in the vicinity of the delta
4. The local climatology (precipitation, frequency of storms, cloudiness, etc.)
5. Gulf (oceanic) circulation in the region
6. Tides
7. Wave action
8. Coriolis force

Currents in the inshore area are due mainly to tides, wind, and river discharge. Other current-producing factors seem to have little effect. The net transport is due to the wind and discharge components, since tidal currents produce no net movement over a tidal cycle.

The highest current speeds are found in the channels and the passages between the islands, and the lowest are found in the open waters of Breton Sound. The surface currents are usually faster than bottom

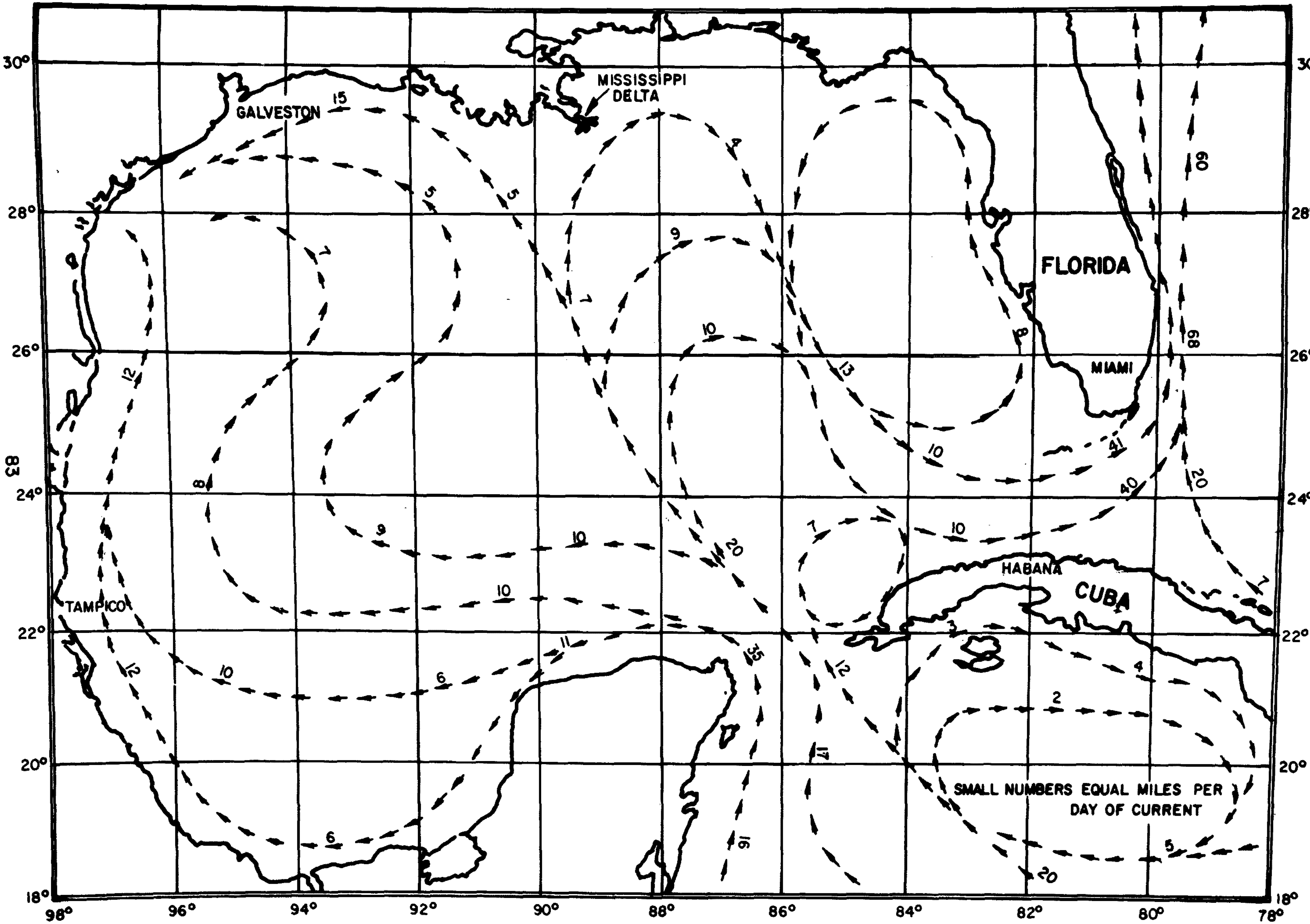


FIGURE 15 —OCEANIC CIRCULATION

currents. Both surface and bottom currents have preferred directions of flow which are normally parallel or sub-parallel. But under some conditions - mainly near the mouths of the outlets - the surface and bottom currents may flow in substantially different or even directly opposite directions.

The tides are diurnal, i.e., only one high and one low water each day. Tidal currents speeds depend on the tidal range (which varies periodically with lunar phases), and on the topography. The tides are the principal current producing forces in the waters east of the delta, and the preferred currents are reversible in the sense that, in the absence of other forces, the net motion during a full tidal cycle is nil.

In the channels on either side of Breton Island the tidal currents flow into the sound on the flood and out on the ebbs. To the west of Breton Island the tidal currents are about the same at all depths, but to the east of the island there is some indication that on the flood the deeper currents are stronger, whereas on the ebb the surface currents are stronger. On the east and north shores of the delta, the surface tidal currents are generally parallel to the shore. The actual times of the beginning of flood or ebb tide at various points in the east delta embayment may differ from the time of high or low water at Passe a Loutre, shown in Figures 16 through 24, by several hours. (6)

If the tidal components of the current are subtracted, the residual surface currents are found to be generally in the direction of the wind with a seaward component. The residual deep currents are slower and usually directed away from the sea.

Wind currents are caused by wind stress on the sea surface, wind induced mass transport of waves, and the piling up of water along the shore when the winds are suitably directed. An empirical relationship predicts that the speed of the surface current due to wind stress will be about two or three per cent of the wind speed. Scruton's experiments in the inshore delta indicate that this is a minimum value. However, these results are based on experiments made with current sensors which, because of their size, must average the current over several inches or more, and which usually must be placed at least several inches below the surface. Recent experiments using dye and drift cards (as flotsam) indicate that the wind induced speed of the top few millimeters is substantially larger than that of a foot or so deeper, and the wind induces alternate low and fast moving bands in the topmost layers that are related to the formation of windrows (7). Tomczak (8), experimenting in the North Sea, determined that the wind induced drift velocity in the surface layers is about 4.2% of wind speed. Stroop (9) found the average drift for fuel oil to be about 4% of wind speed. The amount of fluctuation of the currents from the average direction is also related to the wind. Apart from the changes in current direction associated with tidal changes, the deviations of current direction from wind direction are much less when winds are strong than when they are weak. Changes in wind direction and speed quickly produce changes in the surface currents.

Fresh water emerges from the outlets into the gulf with initial speeds of 0.5 to 3.0 knots depending on river discharge and tidal stage. February through May is the period of high river discharge, and about 53% of the total annual discharge occurs during this time. Under moderately high discharge the maximum surface currents occur just seaward of the channel mouths, where the vertical salinity gradient is sharpest. Down stream of this point, in the gulf, there is a decrease in the vertical salinity gradient and a corresponding decrease in the surface current speed; the surface layer of brackish water thins and spreads laterally as its salinity increases. The areas just seaward of the orifices, where these processes take place, are sites of large scale horizontal turbulence, which dissipates the momentum of the issuing water. Vertical turbulence, though of smaller scale, is probably even more effective in dissipating the momentum of the effluent. Vertical turbulence is increased by high winds and large velocity differences between adjacent layers. Under ideal conditions, (low winds, gulf water moving in the same direction as the effluent) the momentum current may persist for up to 25 miles beyond the channel mouths, but this is rare. Under unfavorable conditions the momentum current is destroyed within less than a mile of the orifice. However, river discharge always strongly affects the circulation in the vicinity of the delta by creating sloping pressure surfaces due to its hydrodynamic head and its alteration of the density distribution.

Under high discharge conditions (greater than 750,000 - 800,000 CFS) no sea water enters the channels, and fresh water flows seaward at all depths regardless of the tide. Under low discharge conditions surface fresh water flows outwards over a layer of denser upstream flowing salt water.

This is known as a "salt wedge", and is a common, though not universal, feature of estuarine circulation. Salt water enters most freely through the deep dredged channels, but apparently also enters all others under approximately the same conditions. The salt water entering through the deeper channels mixes with river water above Head of Passes and is discharged through all channels. This current pattern is subject to substantial modification by tides and wind. During the crisis period, the river discharge was moderately high, averaging about 500,000 CFS. Under these conditions the salt wedge was probably alternately intruded and extruded from the river mouths by the tides, and did not reach very far upstream.

Differences in salt content are the result as well as the cause of the circulation patterns in this area. The salt content changes as a result of mixing of gulf and river water by turbulence due to wind, waves and all types of flow. It influences the circulation by establishing the density gradients which cause the pressure surface to slope. (Suspended matter also affects the bulk water density, and, under certain conditions, may become a significant factor, but the average concentration of suspended matter, probably less than 0.1 gm/l, is small compared to that of dissolved substances.) Within a relatively short distance of the distributory mouths the effect of river discharge on the local circulation comes about mainly through the salinity differences that it has established.

The range of salinities in any particular area is related to its position with respect to the sources of fresh water, to the current system, and to the winds. In the surface waters northwest of Main Pass the salinity usually decreases on the flood tide and increases on the ebb, while to the east, surface salinity decreases on the ebb tide and increases on the flood. This implies a net flow of surface water into Breton Sound to the west of Breton Island and out of the sound to the east of Breton Island. The range of bottom salinities throughout Breton Sound is large, but the values are always less than that of Gulf water. However, at any one location in the sound, the salinity variations with time are relatively small. South of Breton and Gosier Islands the salinity fluctuations are less than those in the waters of the main circulation axis adjacent to the shore of the delta, and the salinity regimen is similar to that inside Breton Sound.

The amount of material in suspension is controlled by the river discharge and the distance from shore. It generally decreases to a small value several miles offshore, but, under certain conditions, plumes of turbid water may extend up to 65 miles from the mouths of the major passes. The direction of the plumes is controlled mainly by the wind, but is also influenced by the current pattern. In the plumes the color change is generally gradual along the axis of elongation and much sharper transverse to this axis. (10)

In general the turbidity contours roughly parallel the salinity contours, but the turbidity gradient is directed opposite to the salinity gradient. The most turbid water resides in a well defined surface layer which is only a few feet thick over wide areas. Frequently ships, even those having shallow drafts, will stir up clear water in their wakes when passing through region of high turbidity.

Perhaps the most striking features of this turbidity are the sharp boundaries which are seen between water bodies of different color. There are usually two or three such boundaries roughly paralleling the shore of the delta. Often, but not always, there is a considerable amount of floating debris associated with these boundaries. This occurs when one water mass is flowing under another, less dense, water mass. The flotsam on the sinking water cannot follow it, and becomes trapped in the boundary region. This type of flow is called a "convergence".

The main convergence zone has been given a name by the local boating people; they call it "the rip". This implies a certain degree of prominence and durability; however, it may really be a feature which occasionally breaks up and becomes re-established along roughly parallel lones some distance away. This would explain the presence of sharp turbidity boundaries without any associated debris. When the convergence process stops, the flotsam would be quickly dispersed by even very light winds, while the boundary between water masses would, especially under calm condition, take hours to vanish due to turbulent diffusion. Since there is a lot of flotsam in this area, it is not likely that a newly-developed convergence could exist for very long without trapping a noticeable quantity of it.

APPENDIX A REFERENCES

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5. Cameron, W. M. and D. W. Pritchard 1963. "Estuaries in the Sea", Vol. II, edited by M. N. Hill, Interscience Publishers, New York, P. 306-324

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7. Katz, B., R. Gerard and M. Castin 1965 "Response of Dye Tracers to Sea Surface Condition", J. Geophysical Res., V.70, No. 22

8. Tomczak, G. 1964 "Investigations with Drift Cards to Determine the Influence of Wind on Surface Currents", Studies on Oceanography, edited by Kozo Yoshide, U. of Tokyo Press

9. Stroop, D. V. 1927 "Report on Oil Pollution Experiments, Behavior of Fuel Oil on the Surface of the Sea, U. S. Dept. of Commerce, Bureau of Standards, Wash., D. C.

10. Scruton, P. G. and D. G. Moore 1953 "Distribution of Surface Turbidity off Mississippi Delta", Bull. Amer. Soc. Pet. Geol., V. 37, No. 10

APPENDIX B - TABULATION OF OCEANOGRAPHIC, METEOROLOGICAL, AND OIL SLICK OBSERVATIONS

Figures B.1 through B.9 summarize and tabulate the available background data and events readily adapted to this format. Included are:

a. Routine wind and sea state observations made by the USCG aboard the New Orleand lightship located at the entrance to the Mississippi-Gulf Outlet Channel about five miles from MP41C (29, 4N, 88.9°W).

b. The tidal cycle at Passe a Loutre, derived from the tide tables of the USC&GS.

c. Pollution observations taken from USCG & USGS SITREPS.

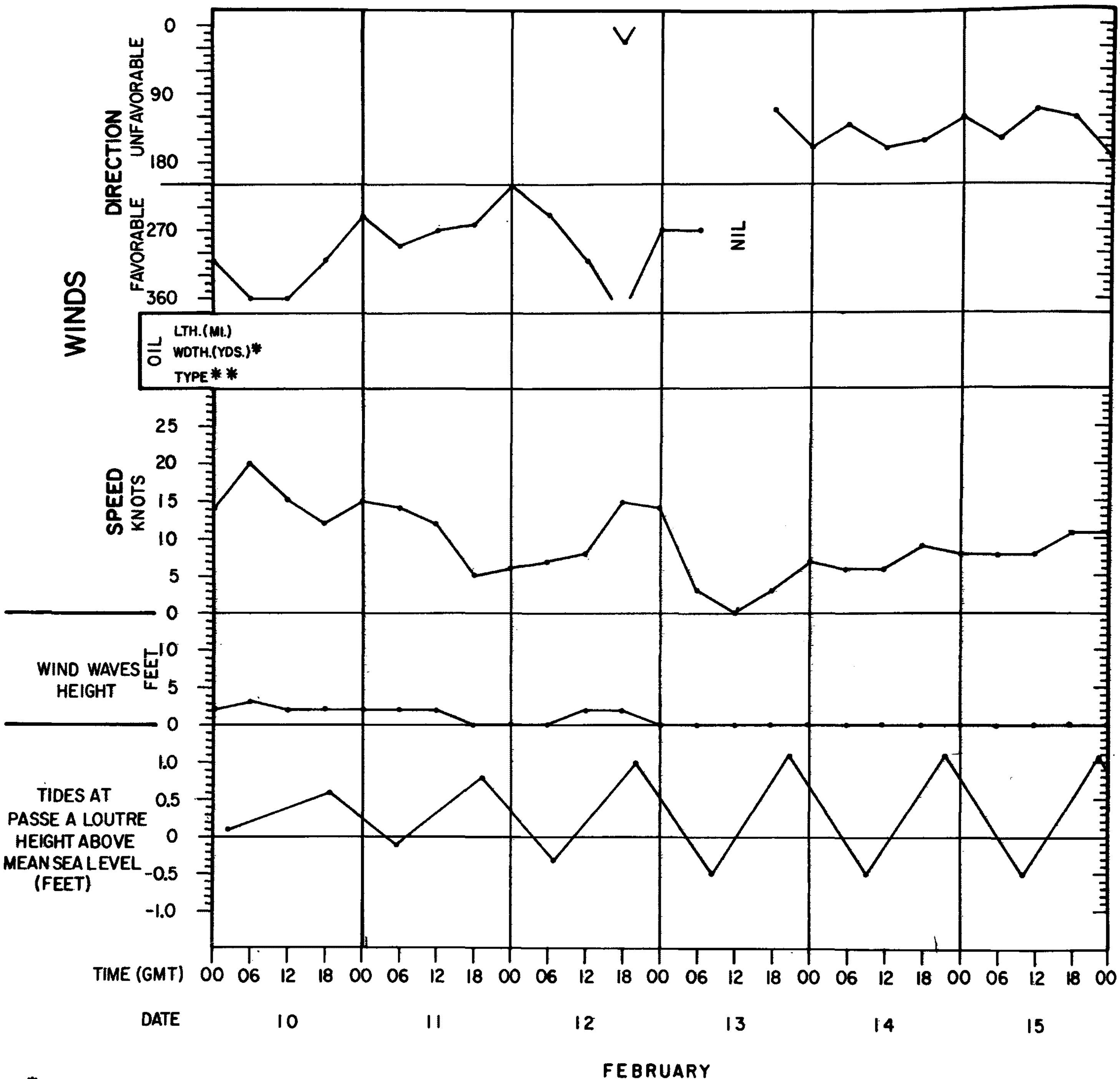
d. Major operational events taken from USCG & USGS SITREPS.

Times in the figure are Greenwich Mean Time (GMT of Z): add six hours to GMT to get local time. The pollution observations are to be used with caution as they are real-time visual reports and estimates, and are not derived from the aerial photos or remote sensing data. Winds are shown in the conventional manner, in the direction from which they blow; and the oil slick (+) notation is given as the direction from which it flows, to conform with the wind notation.

The discussions which follow are based on information developed in previous sections. The results of detailed studies of the aerial reconnaissance and the oceanographic observations (USGS & USCG) are not available at this writing. These should provide additional quantitative information regarding the movement of the oil.

The LSU Coastal Studies Institute, working for the USCG reached the following preliminary conclusions early in their program:

a) The oil does not appear to cross boundaries in the water.
b) The wind-driven currents appear to be dominant with fresh water flow and the tidal currents important but secondary.

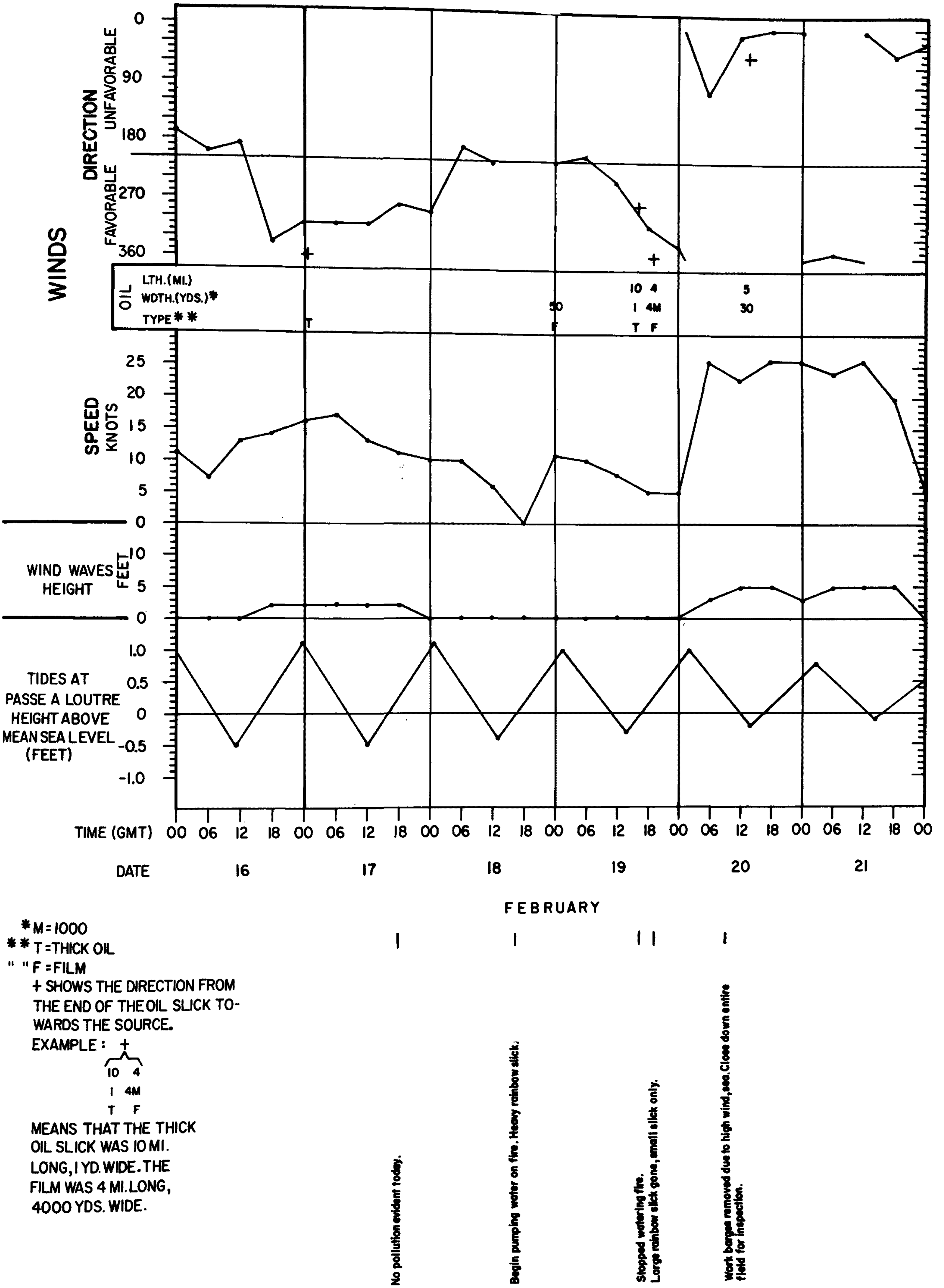


*M=1000
** T=THICK OIL
" " F=FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE: +
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.

Fire reported on MP41C.

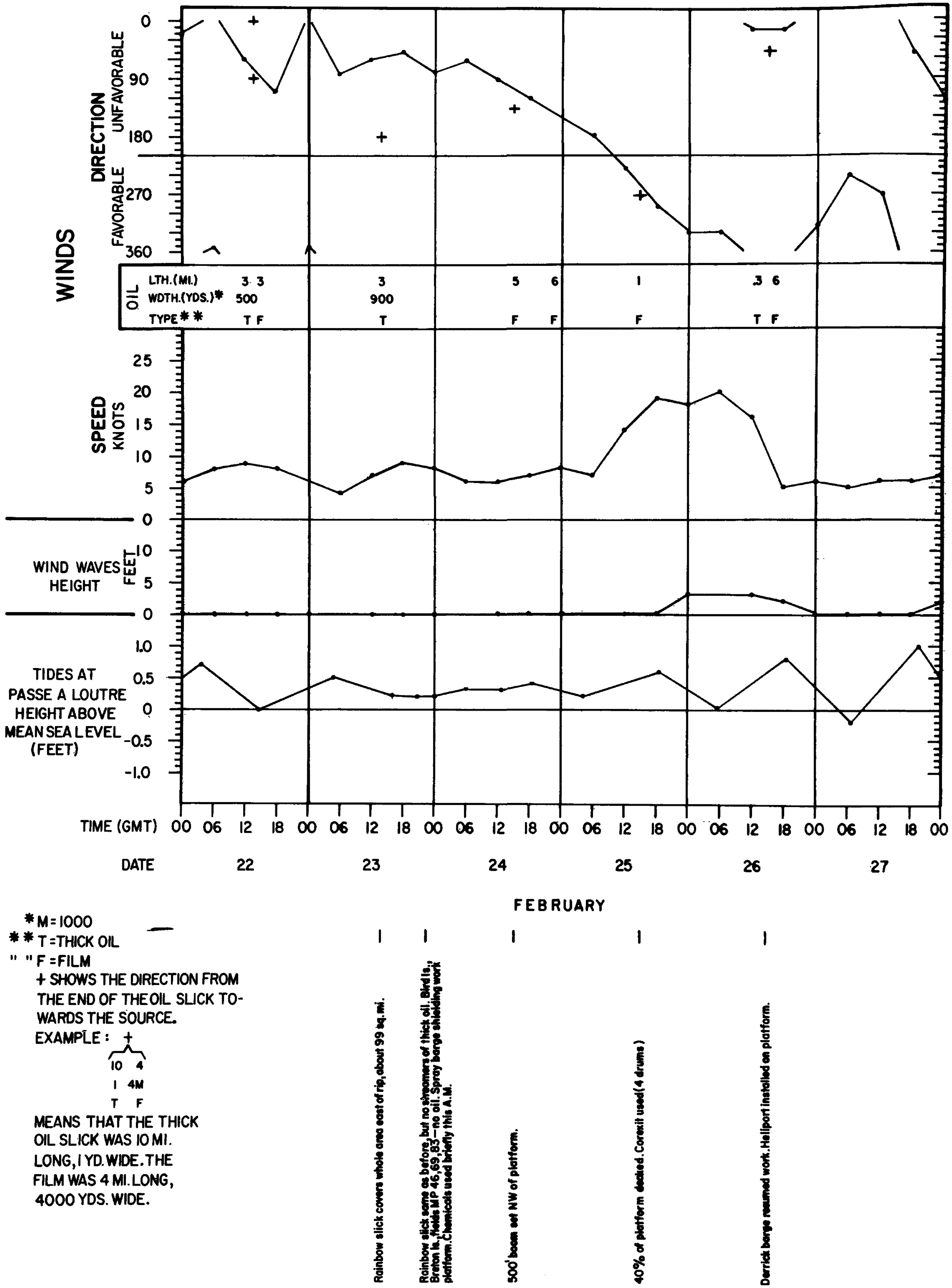
No pollution observed

FIG. 16



WINDS
DIRECTION
UNFAVORABLE
FAVORABLE
0
90
180
270
360
OIL
LTH. (MI.)
WDTH. (YDS.)*
TYPE **
10 4
5
50
1 4M
30
T
F
T F
SPEED
KNOTS
25
20
15
10
5
0
WIND WAVES HEIGHT
FEET
10
5
0
TIDES AT PASSE A LOUTRE HEIGHT ABOVE MEAN SEA LEVEL (FEET)
1.0
0.5
0
-0.5
-1.0
TIME (GMT) 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
DATE 16 17 18 19 20 21
FEBRUARY
*M=1000
** T=THICK OIL
" " F=FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE: +
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
No pollution evident today.
Begin pumping water on fire. Heavy rainbow slick.
Stopped watering fire.
Large rainbow slick gone, small slick only.
Work barges removed due to high wind, sea. Close down entire field for inspection.

FIG. 17


WINDS
DIRECTION
UNFAVORABLE
FAVORABLE
0
90
180
270
360
OIL
LTH. (MI.)
WDTH. (YDS.)*
TYPE**
3 3
500
T F
3
900
T
5
F
6
F
1
F
.3 6
T F
SPEED
KNOTS
25
20
15
10
5
0
WIND WAVES HEIGHT
FEET
10
5
0
TIDES AT PASSE A LOUTRE HEIGHT ABOVE MEAN SEA LEVEL (FEET)
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0.5
0
-0.5
-1.0
TIME (GMT)
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
DATE
22
23
24
25
26
27
FEBRUARY
*M = 1000
** T = THICK OIL
" " F = FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE: +
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
Rainbow slick covers whole area east of rip, about 99 sq. mi.
Rainbow slick same as before, but no streamers of thick oil. Bird Is., Breton Is., fields MP 46, 69, 83—no oil. Spray barge shielding work platform. Chemicals used briefly this A.M.
500' boom set NW of platform.
40% of platform decked. Corexit used (4 drums)
Derrick barge resumed work. Heliport installed on platform.

FIG. 18

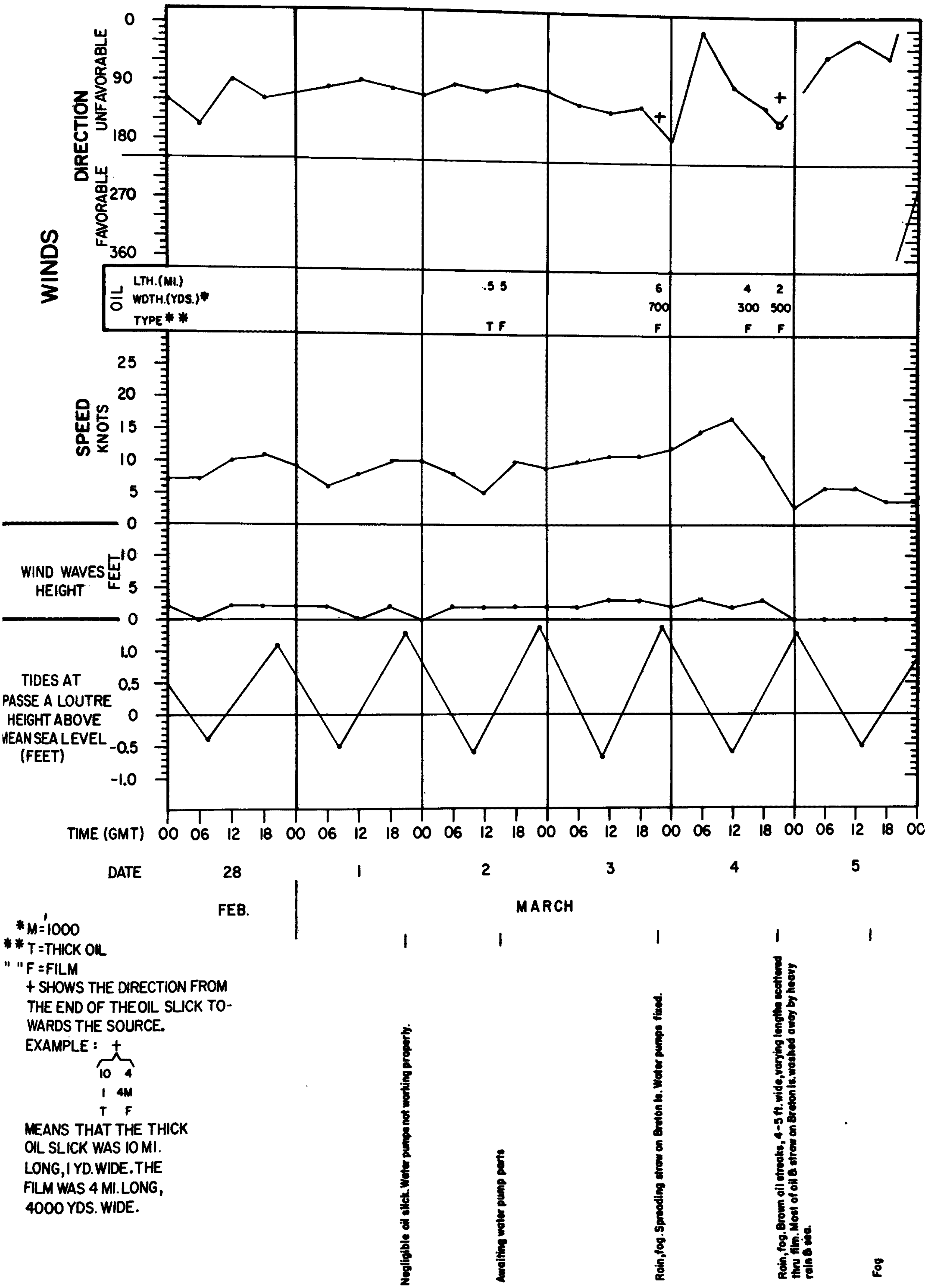
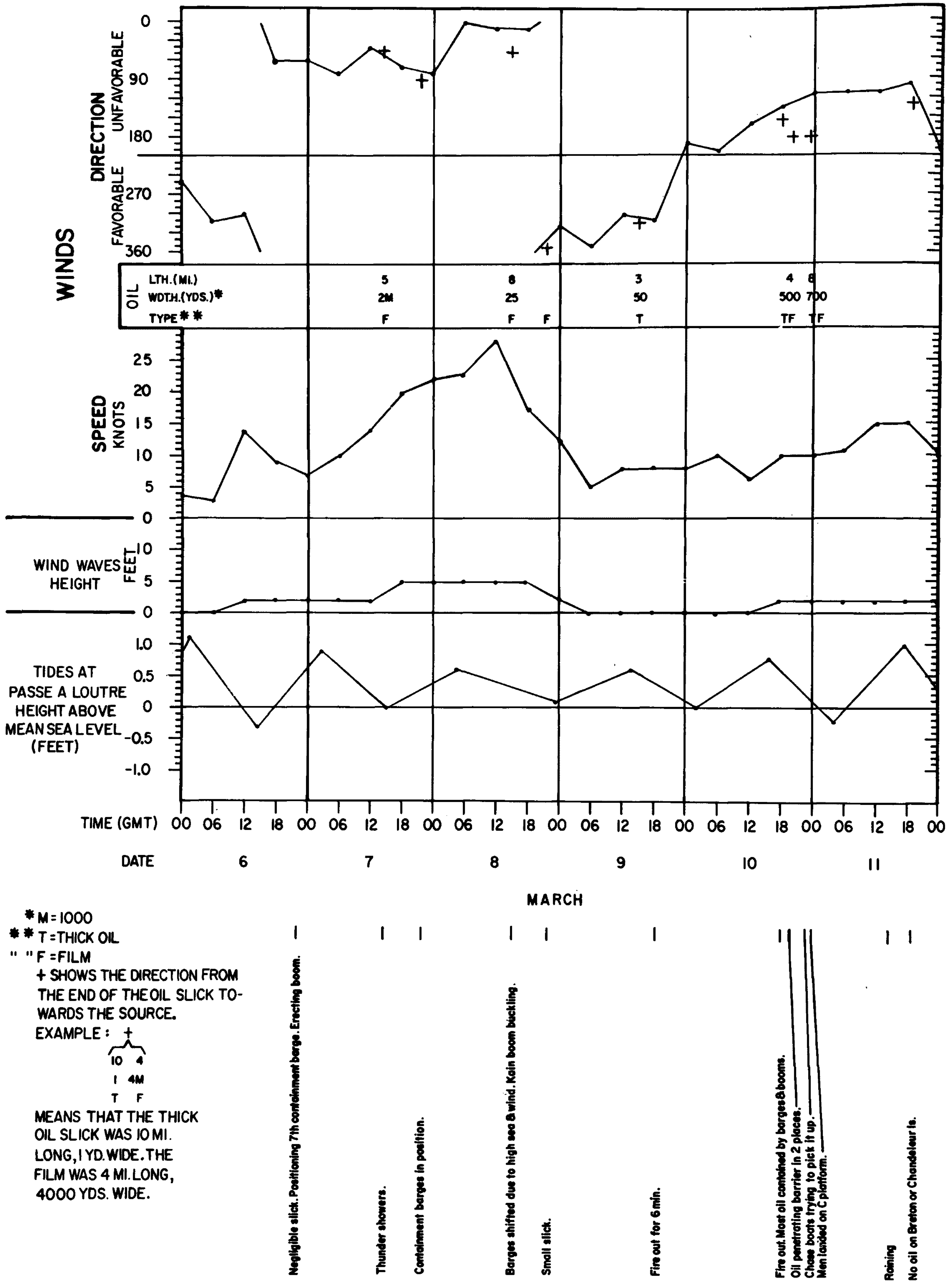

WINDS
DIRECTION
UNFAVORABLE
FAVORABLE
0
90
180
270
360
OIL
LTH.(MI.)
WDTH.(YDS.)*
TYPE **
.5 5
T F
6
700
F
4
300
F
2
500
F
SPEED
KNOTS
25
20
15
10
5
0
WIND WAVES HEIGHT
FEET
10
5
0
TIDES AT PASSE A LOUTRE HEIGHT ABOVE MEAN SEA LEVEL (FEET)
1.0
0.5
0
-0.5
-1.0
TIME (GMT)
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
DATE
28
1
2
3
4
5
FEB.
MARCH
*M=1000
** T=THICK OIL
" "F=FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE: +
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
Negligible oil slick. Water pumps not working properly.
Awaiting water pump parts
Rain, fog. Spreading straw on Breton Is. Water pumps fixed.
Rain, fog. Brown oil streaks, 4-5 ft. wide, varying lengths scattered thru film. Most of oil & straw on Breton Is. washed away by heavy rain & sea.
Fog

FIG. 19


WINDS
DIRECTION
UNFAVORABLE
FAVORABLE
0
90
180
270
360
OIL
LTH.(MI.)
WDTH.(YDS.)*
TYPE **
5 8 3 4 8
2M 25 50 500 700
F F F T TF TF
SPEED
KNOTS
25
20
15
10
5
0
WIND WAVES HEIGHT
FEET
10
5
0
TIDES AT PASSE A LOUTRE HEIGHT ABOVE MEAN SEA LEVEL (FEET)
1.0
0.5
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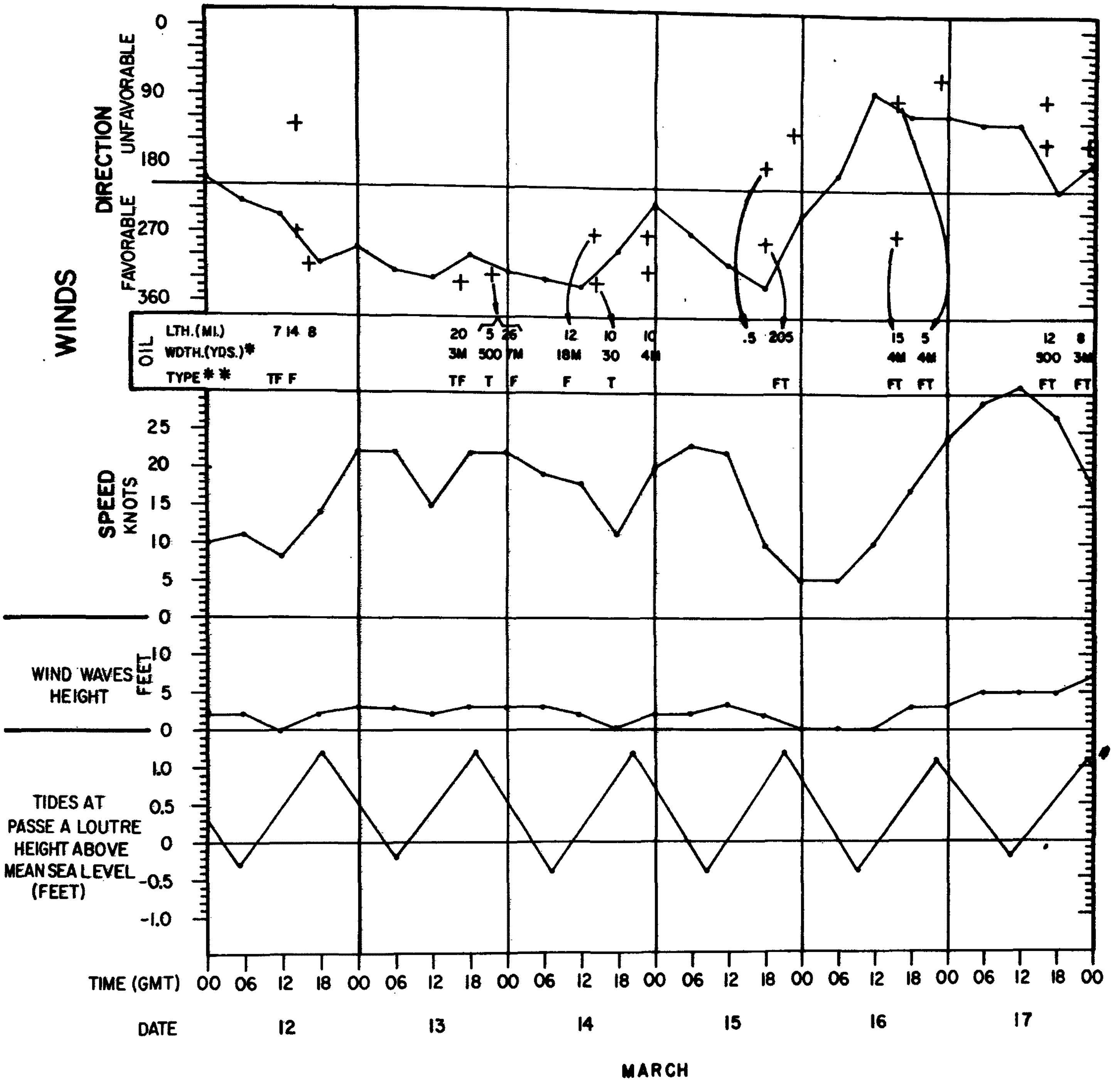
-0.5
-1.0
TIME (GMT)
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
DATE
6 7 8 9 10 11
MARCH
* M = 1000
** T = THICK OIL
" " F = FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE :
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
Negligible slick. Positioning 7th containment barge. Erecting boom.
Thunder showers.
Containment barges in position.
Barges shifted due to high sea & wind. Kain boom buckling.
Small slick.
Fire out for 6 min.
Fire out. Most oil contained by barges & booms.
Oil penetrating barrier in 2 places.
Chase boats trying to pick it up.
Men landed on C platform.
Raining
No oil on Breton or Chandeleur Is.

FIG. 20



*M = 1000
** T = THICK OIL
" " F = FILM
\+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.

EXAMPLE: +
10 4
1 4M
T F

MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.

Heavy slick to 7 mi. E of platform, but oil extended for 14 mi. towards Gosier Is.

Oil herder experiment. Permission to use 1 bbl. chemical per day given.

Burning old straw on Breton Is. No oil found.

Light rain. Well 11 stopped, well 10 capped.

Well 9 stopped. Skimming with push barges only.

Boom sections being repaired.

No oil on beaches.

All booms repaired.

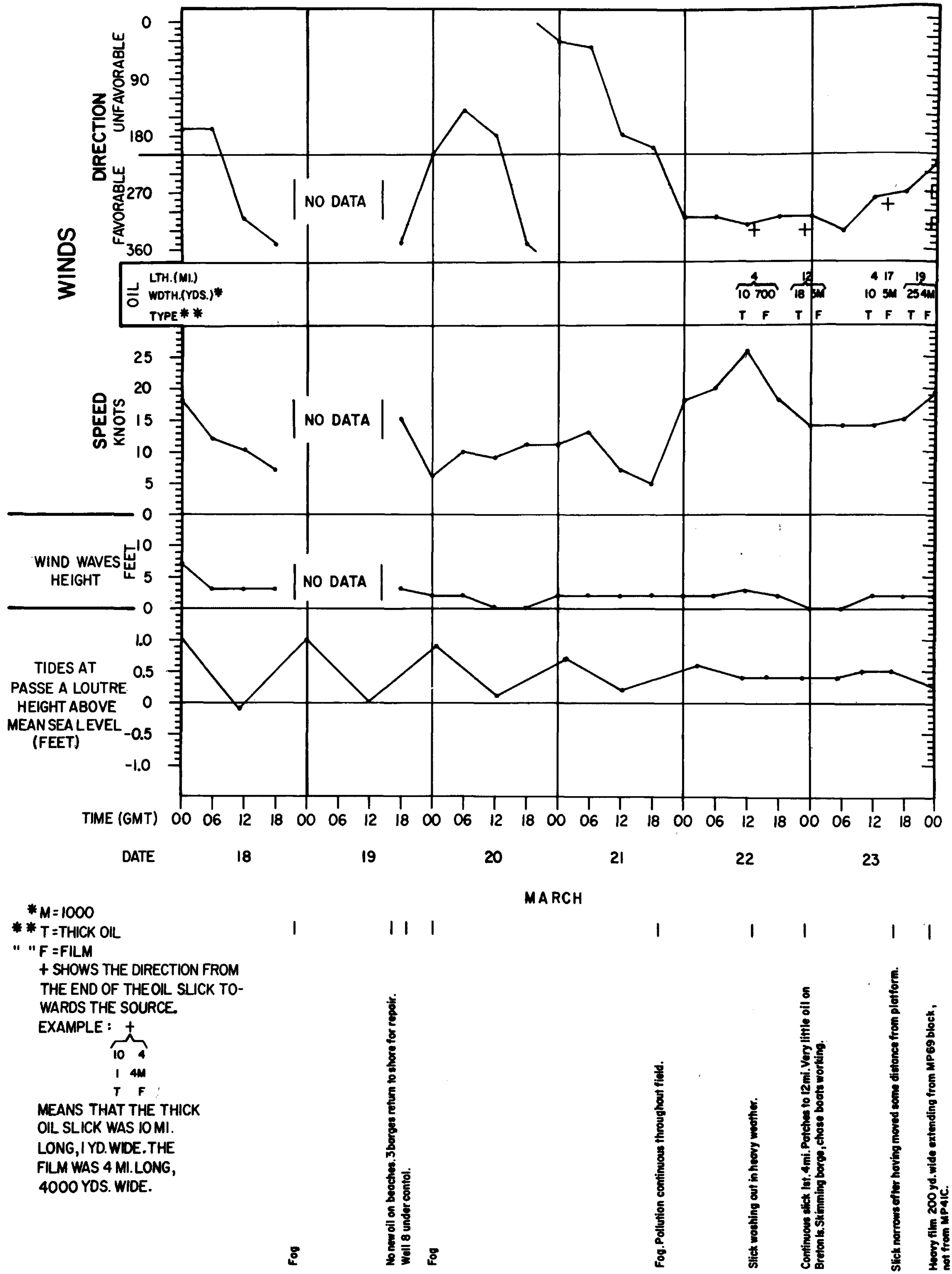
No oil on Breton or Gosier Is. Well 1 capped.

Total pollution extends 5 mi. west, 6 mi. north, 3 mi. east, and 5 mi. south of rig.

Slick extended NW, then turns W. No oil in Black Bay and California Bay.

Severe squall line has passed through area; high wind, heavy seas. Old slick broken up. Some crude on Breton Is.

FIG. 21



WINDS
DIRECTION
UNFAVORABLE
FAVORABLE
0
90
180
270
360
NO DATA
OIL
LTH.(MI.)
WDTH.(YDS.)*
TYPE**
4
10 700
T F
12
18 5M
T F
4 17
10 5M
T F
19
25 4M
T F
SPEED
KNOTS
25
20
15
10
5
0
NO DATA
WIND WAVES HEIGHT
FEET
10
5
0
NO DATA
TIDES AT PASSE A LOUTRE HEIGHT ABOVE MEAN SEA LEVEL (FEET)
1.0
0.5
0
-0.5
-1.0
TIME (GMT)
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DATE
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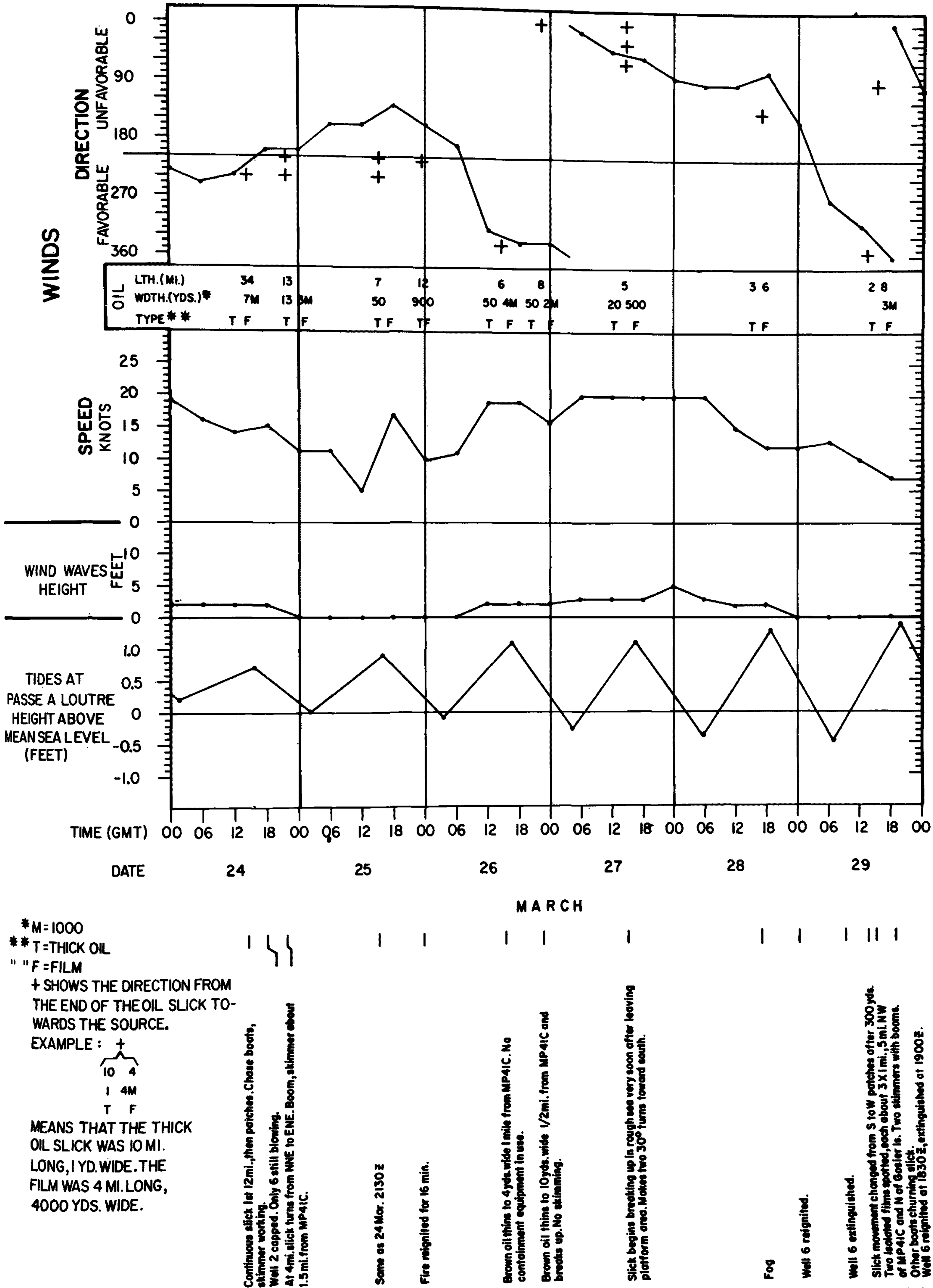
MARCH
*M=1000
**T=THICK OIL
" "F=FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE:
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
Fog
No new oil on beaches. 3 barges return to shore for repair.
Well 8 under contol.
Fog
Fog. Pollution continuous throughout field.
Slick washing out in heavy weather.
Continuous slick 1st. 4mi. Patches to 12mi. Very little oil on
Breton Is. Skimming barge, chase boats working.
Slick narrows after having moved some distance from platform.
Heavy film 200 yd. wide extending from MP69 block,
not from MP41C.

FIG. 22



WINDS
DIRECTION
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FAVORABLE
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OIL
LTH.(MI.)
WDTH.(YDS.)*
TYPE**
34 13 7 12 6 8 5 3 6 2 8
7M 13 5M 50 900 50 4M 50 2M 20 500 3M
T F T F T F TF T F T F T F T F T F
SPEED
KNOTS
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10
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WIND WAVES
HEIGHT
FEET
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TIDES AT
PASSE A LOUTRE
HEIGHT ABOVE
MEAN SEA LEVEL
(FEET)
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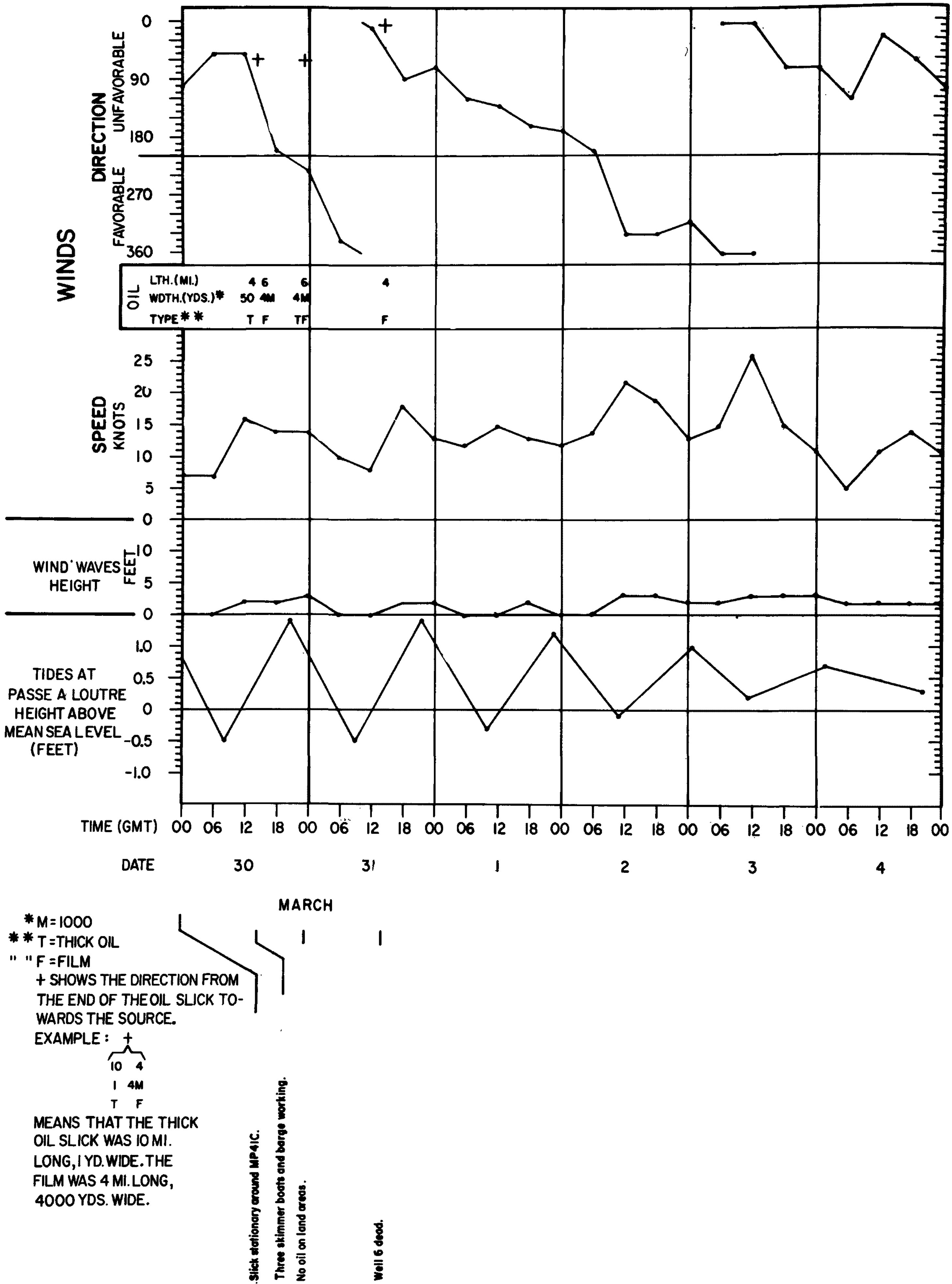
MARCH
*M=1000
** T=THICK OIL
" " F=FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE: +
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
Continuous slick 1st 12mi., then patches. Chase boats, skimmer working.
Well 2 capped. Only 6 still blowing.
At 4mi. slick turns from NNE to ENE. Boom, skimmer about 1.5mi. from MP41C.
Same as 24 Mar. 2130 z
Fire reignited for 16 min.
Brown oil thins to 4 yds. wide 1 mile from MP41C. No containment equipment in use.
Brown oil thins to 10 yds. wide 1/2 mi. from MP41C and breaks up. No skimming.
Slick begins breaking up in rough sea very soon after leaving platform area. Makes two 30° turns toward south.
Fog
Well 6 reignited.
Well 6 extinguished.
Slick movement changed from S to W patches after 300 yds.
Two isolated films spotted, each about 3X1 mi., 5mi. NW of MP41C and N of Goslier Is. Two skimmers with booms.
Other boats churning slick.
Well 6 reignited at 1830 Z, extinguished at 1900 Z.

FIG. 23


WINDS
DIRECTION
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FAVORABLE
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OIL
LTH.(MI.)
WDTH.(YDS.)*
TYPE**
4 6
50 4M
T F
6
4M
TF
4
F
SPEED
KNOTS
25
20
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0
WIND WAVES HEIGHT
FEET
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TIDES AT PASSE A LOUTRE HEIGHT ABOVE MEAN SEA LEVEL (FEET)
1.0
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-0.5
-1.0
TIME (GMT)
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
DATE
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MARCH
*M=1000
** T=THICK OIL
" " F=FILM
+ SHOWS THE DIRECTION FROM THE END OF THE OIL SLICK TOWARDS THE SOURCE.
EXAMPLE: +
10 4
1 4M
T F
MEANS THAT THE THICK OIL SLICK WAS 10 MI. LONG, 1 YD. WIDE. THE FILM WAS 4 MI. LONG, 4000 YDS. WIDE.
Slick stationary around MP41C.
Three skimmer boats and barge working.
No oil on land areas.
Well 6 dead.

FIG. 24

APPENDIX C - BIOLOGICAL RESOURCES

C.1. General Biological Resources

The area involved in the present review comprises coastal marshes and estuarine environments considered to be important habitat areas for fish and wildlife, and valuable nursery grounds for offshore species. This biological resource forms the basis for several important industries including commercial fisheries, sport fisheries, commercial fur production and hunting in addition to non-industrial pursuits such as basic scientific investigation and educational opportunities offered by wildlife refuges.

In addition, there is a great potential in the deltaic area for the extensive development of mariculture operations to provide cultured marine and brackish water food organisms.

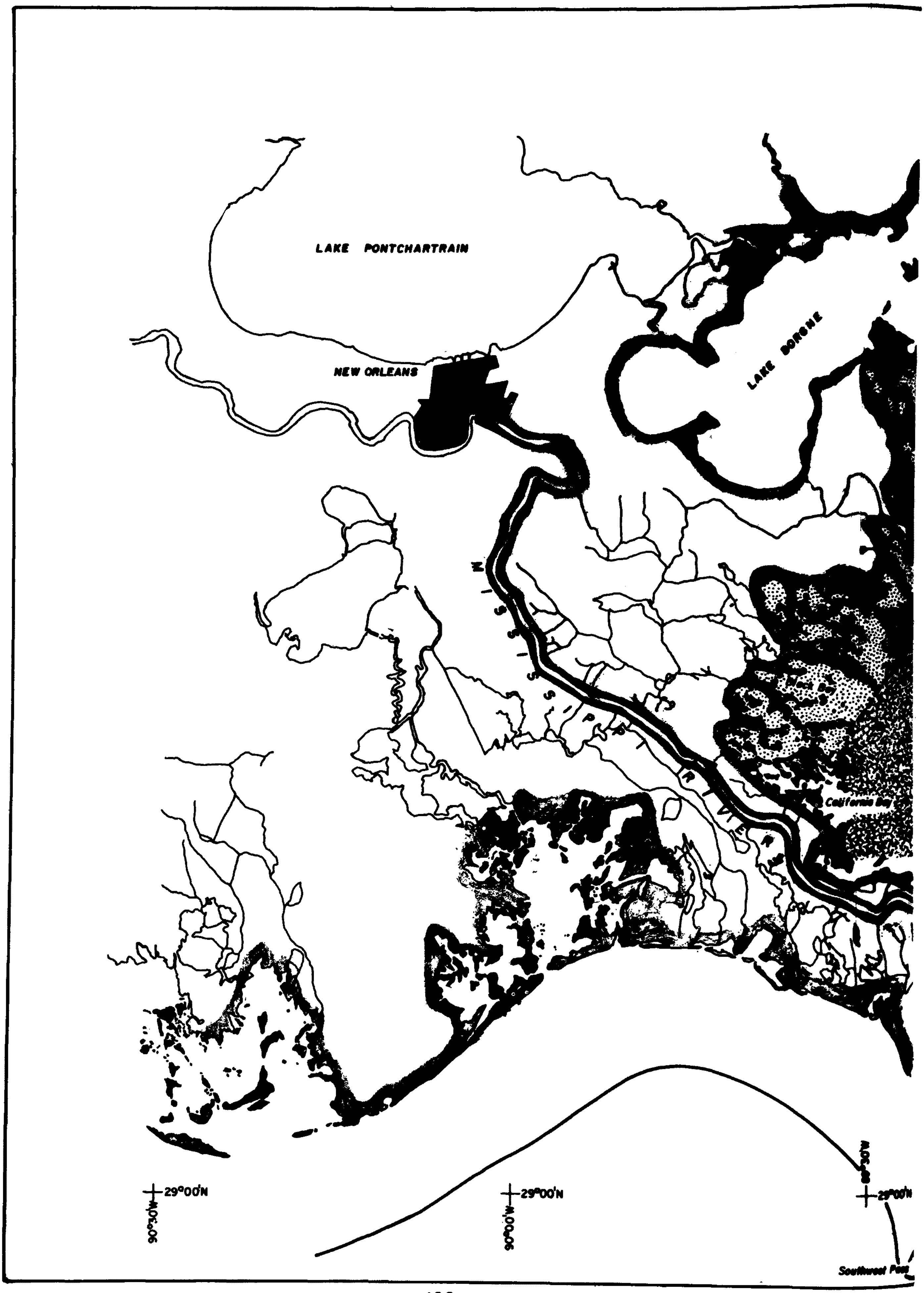
Louisiana ranks first among all states in area of important estuarine habitat. Shrimp, for example, utilize the estuaries as nursery grounds, and Louisiana consistently ranks first or second in shrimp production. In 1969, the state was first with a production of more than 52,000,000 pounds of headless shrimp having a dockside value in excess of $33,400,000 (1). Louisiana, the only state where oysters are harvested the year round, supplies 20 per cent of the total U. S. market. Ten to fifteen million pounds of oysters are produced annually. With the exception of oil and gas, Louisiana's fisheries are its largest industry, and total production of all species often exceeds 1 billion pounds annually. The total annual value of all fishery operations is in the $100 to $140 million range. For a variety of reasons, many commercially important species are underfished. It appears that the blue crab industry in the State could certainly be developed to several times the size of its present $500,000 to $800,000 per year volume. Fur and meat products provided by animals of the estuarine habitat are a several-million-dollar per year business in Louisiana (2).

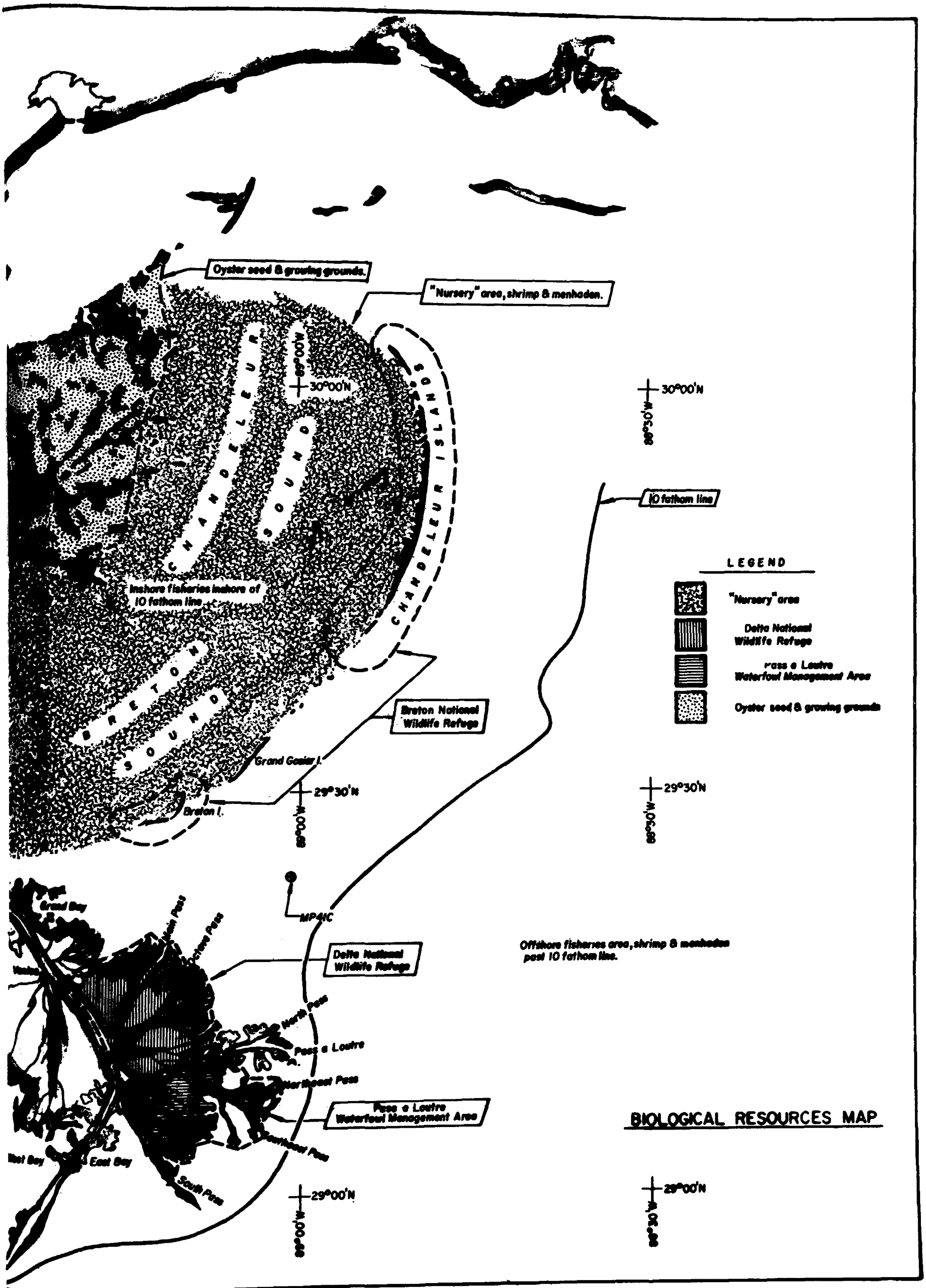
Louisiana's principal capability for conducting coastal and wetland research is concentrated in two organizations, the Louisiana Wild Life and Fisheries Commission and Louisiana State University at Baton Rouge. Utilizing the extensive marshlands of its refuge systems as natural laboratories and its Marine Laboratory at Grand Terre for more controlled work, the LWLFC conducts numerous biological and ecological studies of Louisiana's wetlands.

C.2. Refuges and Sanctuaries

C.2.1. Delta National Wildlife Refuge

Delta National Wildlife Refuge is situated on the Mississippi River Delta in Plaquemines Parish, Louisiana, 75 air miles southeast of New Orleans (Figure 25). The refuge contains 48,800 acres of Deltaic


LAKE PONTCHARTRAIN
NEW ORLEANS
LAKE BORGNE
MISSISSIPPI RIVER
California Bay
29°00'N
90°30'W
29°00'N
90°00'W
29°00'N
89°30'W
Southwest Pass



BIOLOGICAL RESOURCES MAP

FIG. 25

marshes, shallow ponds within the marshes, passes, bayous, and canals. It was established in 1935 primarily as a sanctuary and feeding and resting habitat for large wintering populations of blue and snow geese and more than 18 species of ducks. In some years Delta Refuge winters up to one million ducks and 350,000 geese. It also is a sanctuary for many other water birds, shore birds, white-tail deer, and alligators (3).

The alluvial lands of the refuge are geologically new, having been built up of Mississippi River silt during the last 300 years. Topography is typically deltaic, consisting of a series of low, unstable islands cut by numerous channels, locally known as "passes", and bayous. Solid ground is confined to the immediate banks of the passes, which support stands of willow, grounselbush, coffeebean, and other woody plants, and coarse herbaceous plants. Dogtooth-grass and deer-pea dominate slopes of many pass banks. From the tops of these natural levees the land slopes gradually downward toward the interiors of the islands, its fingers penetrating high marsh, low marsh, and floating marsh, and terminating in open ponds.

The varied and changeable habitat of Delta Refuge shelters abundant birds, mammals, fishes and reptiles of many species. In summer, great blue herons, Louisiana herons, little blue herons, yellow and black-crowned night herons, common and snowy egrets, white and glossy ibises, and various shore birds frequent shallow waters along ponds and passes in their search for food. Least and American bitterns, green herons, rails and gallinules nest in the tangled vegetation. Black skimmers, willets, and terns are numerous. The brown pelican, Louisiana's State bird, once was observed in large numbers but is now infrequently seen.

Delta is a principal wintering area of blue geese. In mid-October the vanguard arrives from remote breeding grounds in the far north. The most abundant ducks wintering at the refuge are the widgeon, gadwall, pintail, shoveler, and green-winged teal. These birds arrive in large numbers in October also. In September numerous blue-winged teal pass through enroute to wintering grounds in the West Indies and Central and South America. The mottled duck is a year-round resident.

Migratory birds normally reach their greatest numbers in early December, and complete their departures northward by the last of March. Nesting song bird populations are limited by the lack of attractive habitat. Tree swallow migrations through the Delta area are exceptionally heavy. The refuge marshes support a herd of whitetail deer. Another mammal at Delta is the nutria or coypu, a large aquatic rodent introduced from South America. It is vegetarian and chews herbaceous or woody plants in the marshes, including desirable waterfowl food plants. Since an initial release of 50 on lands near the refuge in 1950, the population has grown to such proportions - in excess of 50,000 animals by the early 1960s - that an annual harvest is necessary. For several years removals have been accomplished by local trappers under permit. Trappers sell both fur and meat. The latter is utilized in preparing dog, cat and domestic mink foods.

Raccoon are abundant on all marsh areas and are often seen during the day. Cottontails abound in the thick herbaceous and woody cover along pass banks. Otter, mink, and opossum frequent refuge marshes, but are seldom seen. Ponds and bayous provide good alligator habitat. The Bureau of Sport Fisheries and Wildlife is currently engaged in efforts to restore the alligator to the limits of the area it once occupied.

The marshes change in character toward the Gulf as salinity increases, through a typical succession which includes intermediate marshes characterized by Spartina patens (wiregrass), Eichinochloa walteri (wild millet), Scirpus californicus (bullwhip), and Cladium jamaicense (sawgrass); brackish marshes of wiregrass, Scirpus olneyi (three corner grass), Scirpus robustus (coco) and Ruppia maritima (Widgeon grass); and finally, in the lower bay, saline marshes in which the predominant cover is Spartina alterniflora (oyster grass) with occasional thickets of Avicenia nitida (black mangrove), Distichlis spicata and juncus roemerianus.

Refuge ponds also support heavy populations of garfish, catfish, buffalo, mullet and shad. Crappie and largemouth bass frequent some of the fresher interior ponds. Waters near the Gulf are inhabited by sheepshead, stingrays, crabs, shrimp, eels, redfish, flounder, speckled trout, and a variety of other aquatic animals.

The refuge marshes, interlaced with innumerable ponds, natural passes and canals, form a mixing bowl for the fertile waters of the Mississippi River and the saline waters of the Gulf. As a result, the refuge harbors a rich variety of fresh-water and marine fishes.

Studies conducted from August 1963 to January 1965 revealed an abundance of fresh-water and marine fishes cohabiting the refuge waters (4). The refuge is of particular importance as a nursery ground for several species of high commercial and sport value. During the study period, salinities ranged from 0.05 to 15.20 parts per thousand with higher salinities occurring in ponds and passes north of Main Pass. Salinities were at a minimum in the spring and summer and gradually increased in the fall and winter. Water temperatures varied seasonally with extremes of 11.1°C to 35.5° C. The temperature of pond waters was generally 1 to 2 degrees higher than that of the passes.

This resulting fish list, Table 3 , representing 33 families and 75 species, has been compiled by John R. Kelly, Jr., and Dudley C. Carver who conducted the above studies in cooperation with the Louisiana Cooperative Fishery Unit and Louisiana State University. Names of fishes used in this list are in accordance with "A List of Common and Scientific Names of Fishes from the United States and Canada" (American Fisheries Society, 1960). The species are listed as to usual habitat (freshwater-F or Marine-M), and as to abundance (abundant-a, common-c, uncommon-u), and seasonal occurrence (spring-SP, summer-S, fall-F, and

TABLE 3 FISHES OF THE DELTA NATIONAL WILDLIFE REFUGE

SPECIES	F or M	Sp	S	F	W
CARANGIDAE--jacks, scads, pompanos					
Crevalle jack, *Caranx hippos*	M		c	c	
Leather jacket, *Oligoplites saurus*	M		c	c	
GERRIDAE-mojarras					
Yellowfin mojarra, *Gerres cinereus*	M	u	u	u	u
SCIAENIDAE-drumms					
Freshwater drum, *Aplodinotus grunniens*	F	c	c	c	c
Silver perch, *Bairdiella chrysura*	M		c	c	
Sand seatrout, *Cynoscion arenarius*	M	c	c	c	c
Spotted seatrout, *Cynoscion nebulosus*	M	c	c	c	c
Spot, *Leiostomus xanthrurus*	M	c	c	c	c
Gulf kingfish, *Menticirrhus littoralis*	M		u		
Atlantic coraker, *Micropogon undulatus*	M	a	a	a	a
Black drum, *Pogonias cromis*	M		c	c	c
Red drum, *Sciaenops ocellata*	M		c	c	c
SPARIDAE--porgies					
Sheepshead, *Archosargus probatocephalus*	M		c	c	
Pinfish, *Lagodon rhomboides*	M		c	c	
SCOMBRIDAE--mackerels and tunas					
Spanish mackerel, *Scomberomorus maculatus*	M		u		
ELEOTRIDAE--sleepers					
Fat sleeper, *Dormitator maculatus*	FM	a	a	a	a
Spinycheek sleeper, *Eleotris pisonis*	FM	a	a	a	a
GOBIDAE--gobies					
Lyre goby, *Evorthodus lyricus*	M	c	c	c	c
Violet goby, *Gobioides broussonetti*	M	c	c	c	c
Darter goby, *Gobionellus hastatus*					
Sharptail goby, *Gobionellus hastatus*	M	c	c	c	c
Freshwater goby, *Gobionellus shufeldti*	FM	a	a	a	a
Spottail goby, *Gobionellus stigmaturus*	M	u	u	u	u
Naked goby, *Gobiosoma bosci*	M	c	c	c	c
MUGILIDAE-mullets					
Striped mullet, *Mugil cephalus*	FM	a	a	a	a
ATHERINIDAE--silversides					
Rough silverside, *Membras martinica*	M		c	c	
Tidewater silverside, *Menidai beryllina*	FM	a	a	a	a
BOTHIDAE--lefteye flounders					
Bay whiff, *Citharichthys spilopterus*	M	c	c	c	
Fringed flounder, *Etropus crossotus*	M	c	c	c	
Southern flounder, *Paralichthys lethostigma*	M	a	a	a	
SOLEIDAE--soles					
Lined sole, *Achirus lineatus*	M			u	
Hogchoker, *Trinectes maculatus*	M	c	c	c	
CYNOGLOSSIDAE--tonguefishes					
Blackcheek tonguefish, *Symphurus plagiusa*	M				u
HIODONTIDAE--mooneyes					
Goldeneye, *Hiodon alosoides*	F		u		

SPECIES	F or M	Sp	S	F	W
CYPRINIDAE--minnows and carps					
Golden shiner, *Notemigonus crysoleucas*	F	c	c	c	c
Blacktail shiner, *Notropis venustus*	F		u		
CATOSTOMIDAE--suckers					
River carpsucker, *Carpiodes carpio*	F	a	a	a	a
Smallmouth buffalo, *Ictiobus bubalus*	F	u	u	u	u
Bigmouth buffalo, *Ictiobus cyprinellus*	F	c	c	c	c
ARIIDAE-sea catfishes					
Gafftopsail catfish, *Bagre marinus*	M			c	c
Sea catfish, *Geleichthys felis*	M		c	c	c
ICTALURIDAE-freshwater catfishes					
Blue catfish, *Ictalurus furcatus*	F	a	a	a	a
Yellow bullhead, *Ictalurus natalis*	F	u	u	u	u
Channel catfish, *Ictalurus punctatus*	F	u	u	u	u
ANGUILLIDAE--Freshwater eels					
American eel, *Anguilla rostrata*	FM	a	a	a	a
BELONIDAE--needlefishes					
Atlantic needlefish, *Strongylura marina*	M		c	c	
CYPRINODONTIDAE--killifishes					
Sheepshead minnow, *Cyprinodon variegatus*	FM	c	c	c	c
Gulf killifish, *Fundulus grandis*	FM	c	c	c	c
Saltmarsh topminnow, *Fundulus jenkinsi*	FM	c	c	c	c
Starhead topminnow, *Fundulus notti*	F	u	u	u	u
Rainwater killifish, *Lucania parva*	FM	a	a	a	a
POECILIIDAE--livebearers					
Mosquitofish, *Gambusia affinis*	F	u	u	u	u
Sailfin molly, *Mollienesia latipinna*	FM	a	a	a	a
SYNGNATHIDAE--seahorses, etc.					
Gulf pipefish, *Syngnathus scovelli*	FM	a	a	a	a
SERRANIDAE--sea basses					
White bass, *Roccus chrysops*	F	c	c	c	c
Yellow bass, *Roccus mississippiensis*	F	c	c	c	c
LUTJANIDAE--snappers					
Gray snapper, *Lutjanus griseus*	M			u	
CENTRARCHIDAE--sunfishes					
Warmouth, *Chaenobryttus gulosus*	F	a	a	a	a
Orangespotted sunfish, *Lepomis humilis*	F	u	u	u	u
Bluegill, *Lepomis macrochirus*	F	a	a	a	a
PERCHIDAE--perches					
Gulf darter, *Etheostoma swaini*	F		u		

winter-W.).

C.2.2. Passe-a-Loutre Water Fowl Management Area

The 66,000 acre Passe-a-Loutre Waterfowl Management Area located at the mouth of the Mississippi River, adjacent to the Delta National Wildlife Refuge, provides some of the finest duck hunting offered in the state. This tract of land was set up in 1921 by an Act of Legislature as a public shooting area and is located at the extreme end of the Mississippi Flyway in Plaquemines Parish to the west of the Chevron well MPC41. Refer to Section C.2.1. for biological description of this area.

C.2.3. Breton National Wildlife Refuge

Breton Island, Grand Gosier Island, and the Chandeleur Islands comprise a major bird sanctuary for indigent and migratory birds in the area east of the Mississippi River. This extensive sanctuary lies due north of the Chevron Platform MPC41.

The Gulf Island National Wildlife Refuges consist of a number of islands lying offshore from the State of Louisiana and Mississippi. They were set aside chiefly for the protection of migratory waterfowl and a variety of colonial nesting birds and are administered by the Bureau of Sport Fisheries and Wildlife, in the U. S. Department of the Interior. Supervised from a single office in Biloxi, Mississippi, there are three units: Breton National Wildlife Refuge in St. Bernard and Plaquemines Parishes, Louisiana, and Horn Island and Petit Bois National Wildlife Refuges in Jackson County, Mississippi.

Breton National Wildlife Refuge was established in 1904. It is in two parts: Breton Island proper, and the long, crescentic chain of the Chandeleur Islands. This refuge, off the northeastern part of the great Mississippi River Delta, contains 7,512 acres.

Breton Island is actually two adjacent islands, with a combined length of 5 miles and width of less than 1 mile. The islands are about 12 miles from the Mississippi Delta. They are partly covered by a low growth of black mangrove and black rush, and have shallow salt-water marshes on the mainland side. In winter, waterfowl use the shallows near the islands, and in summer the beaches have nesting colonies of royal terns, Sandwich terns, and black skimmers. An oil company has drilled a number of wells in the bed of the sea about the islands, and has constructed an oil collection station on the northern island.

The Chandeleur Islands make up the greatest part of the Breton Refuge. They are a series of barrier islands forming a crescent 35 miles long, but averaging less than a mile in width. Their northern end is almost 25 miles from the Mississippi coast, from which they are mainly visited. They are low, with a fine sandy beach along the Gulf side, and fall off on the Chandeleur Sound side into a maze of ponds and inlets and marshes. Their vegetation is similar to that of Breton Island. Shoals along the

Sound side provide excellent wintering habitat for redhead ducks. The redheads find an abundance of food here and when the weather is rough they can rest on the interior ponds. In summer, colonies of laughing gulls, royal, Sandwich and Caspian terns, and black skimmers are found on the beaches, and common and snowy egrets nest in the mangroves. The islands are particularly favored by sea turtles looking for a place to deposit their eggs. Despite the islands' distance from the mainland, they are frequently visited by boat in spring and summer by fishermen and picnickers. During the late fall and winter months they are closed to human use to give maximum protection to waterfowl.

Personnel from the Gulf Island National Wildlife Refuge system are directly responsible for surveillance of the Breton Island National Refuge.

U. S. Coast Guard situation reports, dated March 4, and March 17, indicate some oil on the beaches of Breton Island. Contamination estimated on March 4 was approximately 20 barrels. A clean-up crew was maintained on Breton Island by the Chevron Oil Company during the present oil spill.

C.3. COMMERCIALLY IMPORTANT FISHERIES

C.3.1. Gulf Menhaden Brevoortia Patronus

The menhaden is not normally used for direct consumption; its catches are processed into meal, oil, and condensed solubles. The meal is rich in protein and makes an excellent food supplement for poultry, hogs, mink, and other animals. The oil is used in various commercial products including paints, soaps, and lubricants (5).

U. S. fishermen catch more pounds of menhaden each year than any other species. Landings for the Atlantic coast reached a record high in 1956 of about 1.6 billion pounds, valued at about $20 million. In 1963, the catch began to decline drastically. Prior to 1963 most of the U. S. catch was made on the Atlantic coast, but now more menhaden (chiefly B. patronus, the Gulf menhaden) are caught in the Gulf of Mexico.

Menhaden normally occur in dense schools and are caught mostly with purse seines. The carrier vessels are fairly large; most range from 100 to 200 feet long. Each can carry from 125 to over 350 tons of fish. One common fishing technique entails the use of two 36-foot seine boats that are carried to the fishing grounds on the carrier vessel. The purse seine, about 200 fathoms long and 10 fathoms deep, is placed aboard the two smaller boats, half in each boat. Increased fleet efficiency has been accomplished in recent years by using airplanes, which spot schools of menhaden and direct the setting of the nets by radiotelephone. The seine boats, circling the school in opposite directions, let out the net to surround the fish. The bottom of the net is then closed, or pursed, and its sides pulled into the boats with hydraulic blocks until the catch is concentrated. The carrier vessel then pumps the catch into its hold.

Menhaden spawn in the ocean over the continental shelf. Most spawning apparently takes place during November to March. An individual female may spawn from 40,000 to 700,000 eggs, depending on the size of the fish. After fertilization, the eggs float near the surface and hatch in about two days. The larvae enter the estuarine nursery areas when they are nearly 1 inch long and eventually move into the tributaries near the upper limits of salt water where they transform from slender, transparent individuals into deep-bodied juveniles resembling adult menhaden. From time of entry in January-February until autumn, when seasonal chilling of the water apparently causes a general exodus, about 8 months are spent in the shallow, inshore nursery areas. Some juveniles may overwinter in the sounds and bays particularly during mild winters. Yearlings and adults usually are associated with nearshore waters but may appear in certain bays and lower estuaries.

When they metamorphose into juveniles, larval menhaden undergo extensive changes particularly in their feeding and digestive structures. The larvae feed selectively on individual, planktonic animals, whereas the juveniles and adults, whose gill arches support a basketlike sieve capable of retaining very small organisms, are non-selective feeders that obtain food by swimming with mouths gaped, filtering minute plants and animals from the surface water.

Predation and parasitism are apparent, but their effects on the menhaden resource are not known. Menhaden are preyed upon by many other fishes as well as by marine mammals and birds. Bluefish, mackerels, sharks, porpoises, and other carnivores often are seen near menhaden schools. The menhaden is infected with various internal and external parasites. The more conspicuous are the copepod crustacean which attaches itself and forms egg cases that stream along the side or back of the fish, and the isopod crustacean that attaches itself inside the fish's mouth, thus giving rise to the local name "bugfish" for menhaden.

A number of environmental factors may affect the menhaden resource. Extremely low winter water temperatures or pollution may cause heavy mortalities of larvae and juveniles in the estuaries. Also, conditions in the ocean such as water temperature, salinity and food may influence the distribution, movement, and even the success of spawning.

Menhaden grow rapidly during the first 3 years of life. On the average, fish in the catch weigh about a half pound as 1-year olds, nearly a pound as 3-year olds, and then grow less each year until reaching about 1-1/2 pounds as 9-year olds.

C.3.2. Gulf Oyster *Crassostrea virginica*

Three species of oysters are used commercially in the United States. The Eastern oyster, *Crassostrea virginica*, is the most abundant and is found in brackish waters of the bays and inlets along the Atlantic and Gulf coasts. The tiny native Olympia oyster (*Ostrea lurida*) and the large Pacific or Japanese oyster (*Crassostrea gigas*) are farmed along the West Coast. The Japanese species has been called the "immigrant oyster" because it was introduced into the Pacific estuaries from Japan. The young oyster, or "seed", is shipped from Japan each year and is grown to harvestable size in American waters.

In recent years, the total annual production of oysters from 19 coastal states has varied between 52 and 60 million pounds of meats valued at $27 to $33 million to the oyster harvester (6). Measured in another way, the volume could be estimated at 12 million bushels, or approximately 3.6 billion individual oysters. The highest level of production, reported in 1908, was 152 million pounds, or 2-1/2 times the current yield.

The major factor in the decline of the oyster is changes in the environment. The destruction of growing areas by industrial and domestic pollution, dredging, silting, and shoreline housing developments have all taken their tolls. Another factor is the variety of predators that feed on oyster larvae and small oysters. The predators include jellyfish, crabs, worms, fish and other shellfish. When they are fully grown, oysters continue to be food for starfish, drills or boring snails, and certain fish such as the so-called "black-drum" and skates.

In the last 10 years, biologists have become increasingly aware of a number of protozoan parasites that cause oyster mortalities. The most destructive, MSX (*Minchinia nelsoni*), has drastically reduced oyster production in Delaware Bay and lower Chesapeake Bay. Oyster farming practices have been changed in those areas to avoid the parasite. Hurricanes in 1950 all but destroyed the New York oyster resource, and in 1966, the production in the Gulf of Mexico was reduced by half because of another vicious hurricane.

Because the oyster was among the first foods used in America, it was also first to be regulated. Town, county, and state laws regulate the harvest and the kind of gear an oysterman may use. It has been estimated that of the 1,4000,000 acres of bottom which can grow oysters in the U. S. coastal water, 185,000 acres are privately controlled. These leased beds produce 50 per cent of the oyster crop.

The regulations regarding the production of oysters, particularly the method of harvest, vary somewhat from state to state. There is great need to make these regulations more uniform among the various oyster-producing states. One approach to this problem is within the framework of the Atlantic States Marine Fisheries Commission. It was organized, in part, to permit the various states to correlate their regulations in the light of current knowledge about the individual species of marine animals. There is great need of such correlation in order to realize the full potential of oyster farming.

In addition to the regulations by states and their subdivisions in terms of production, the sanitary aspects of oysters as a safe food produce another set of regulations, usually under the jurisdiction of the state health agencies. Marine waters producing oysters must be of the same high quality as fresh drinking water, and in all lower quality waters the taking of shellfish is prohibited. The states survey a total of 4,879,300 acres for water quality; 3,575,200 are approved, but 1,234,900 are closed, usually because they are polluted. These closed areas represent expense for policing and an economic waste of the resource.

In Louisiana, the Louisiana State Board of Health, Division of Public Health Engineering carries out oyster water surveys and is responsible for evaluating the sanitary quality of the growing areas involved. Samples are analyzed for chemical, biological and radiological analyses on a regular basis. This is done as a part of the U. S. Public Health Services program for the sanitation of the harvesting and processing of shellfish.

The oyster's soft body lies in the deeper of the two shells that are hinged at one end. The outside of the shells is rough but the inside is smooth. The body, containing organs of digestion and reproduction, a nervous system, and a circulatory system is enfolded by a mantle that grows and repairs the shell. A thick adductor muscle attached to each shell controls the opening and closing of the shells. Oysters get their oxygen with gills as the sea waters are pumped through them. The gills also filter out the food items which then move into the digestive tract. The pumping of sea water and the filtering of food depends on the water temperature and on materials in the water. A toxic substance will cause the oyster to close the shells. Feeding ceases also when the water becomes too cold (about 40°F). The oyster can pump an average of 3 gallons of water per hour when the temperature is in the 80s (°F). For short periods of time, oysters have been observed to pump at a rate of 10 gallons per hour.

An oyster's growth and maturity depend on temperature, availability of food, and season of the year. In general, the southern oyster grows to market size in two years, while its more northern relative requires 4 years.

The vast majority of young oysters function as males when they first spawn. By the time they spawn the second time, the ratio of the sexes is approximately equal.

When the gonads of the oysters are mature and the water is at the "spawning temperature", an entire oyster bed will spawn, casting billions of eggs and spermatozoa into the water. Embryonic and free-swimming larvae stages develop rapidly. Usually within two weeks the final free-swimming larvae stages glide over hard surfaces (cultch) on a ciliated foot in search of a suitable spot on which to cement itself. A newly "set" oyster is called a "spat". It quickly metamorphases, losing its "eyes" (two internal pigment spots), foot, and swimming appendage. When many larvae set, hundreds may attach in a relatively small area. Within a few weeks of growing, the young oysters on a heavily-set area crowd against one another. Some may be pried off the cultch and survive as single oyster; many more are overgrown by the more rapidly growing neighbors or by those more advantageously placed. Depending upon the length of the growing season, oysters are sexually mature within one or two years after setting.

The east side of the river lies in the heart of the Louisiana oyster growing region and encompasses nearly all of the oyster seed grounds, some 450,000 acres, and about 30% or 40,000 - 50,000 acres of private leases.

The upper Louisiana marshes, east of the river are a rich natural seed oyster area. In 1966 and 1967, extensive plantings of clam shells were made for oyster cultch in the Black Bay area which resulted in increased catch of oyster spat. These spat then were able to provide seed oysters to fishermen who lease state marshlands for oyster production. This seeding is an on-going program sponsored and supported jointly by Louisiana and the Federal Government through Public Law 88-309, the Commercial Fisheries Research and Development Act. This area lies northwest of the Chevron well MPC41.

The oyster farming procedure involves, generally the removal of seed oysters from the state-managed seed grounds east of the Mississippi River to private leases on both sides of the river where the seed oysters are tended, cultivated and fattened before marketing. This operation is generally on an annual basis with the season starting September 1 and harvest usually being completed by the following May.

Tonging is one of the principal methods of harvesting oysters. Since the earliest days, tonging has been done from relatively small skiffs and occasionally from larger vessels powered by oars, poles, and sails until the early 1930s.

Tonging, usually involving a crew of one or two, is performed from flat bottom skiffs, which are 16 to 18 feet long, 5 to 7 feet wide, and powered by an outboard motor. A pair of tongs is an elongated basket-like apparatus with 8 to 12 foot handles, depending on depth fished. Oystermen position their skiffs over the reef and extend the tongs down to the oysters, simultaneously moving the handles in a scissorlike motion to work oysters into the tongs in a groping manner. When the tongs are full, they are hauled on deck, the contents are deposited on a culling board and sorted. Shells and small oysters are returned to the water. This process is repeated until the day's catch is made.

Dredging is the other principal method of harvesting oysters. Prior to 1900, dredging was done from sailing vessels in much the same way as it is today with the exception that loaded dredges were retrieved by a hand-operated winch. The early 1900s saw installation of small gasoline engines on some vessels to power dredge winches. On dredging vessels, the winch that operates dredges now receives its power from the main engine.

A multiple-purpose vessel powered by a diesel engine, known as the

Biloxi lugger, is now used in dredging operations. This vessel ranges from 30 feet length overall with a 9-foot beam and a 2-1/2-foot draft to 60 feet overall with a 17-foot beam and a 5-foot draft. Most are about 52 feet long with a 15 to 16 foot beam and a draft of about 4-1/2 feet. The vessel has a crew of 3 to 5 men.

A dredge is made of metal and has two triangular-shaped sides welded or riveted together with braces and rods. A net with metal link webbing in the bottom half and heavy twine in the top is attached to the frame. A toothed metal bar extends across the lower hind portion of the frame immediately forward of the net. Two dredges are usually operated from a vessel; one from each side, one slightly in front of the other. A dredge is towed over the reef until full and retrieved by a power winch. The contents are emptied on a culling board, sorted and stowed. This process is repeated until the day's catch is made.

C.3.3. Gulf shrimp, brown Penaeus aztecus; white Penaeus setiferus; and pink Penaeus duorarum

The Gulf of Mexico shrimp fishery is the most valuable U. S. fishery. Its average annual U. S. landings were 107 million pounds of shrimp (tail weight) valued at $55 million to the fishermen, in the five years, 1959 - 1963. Three kinds of shrimp - brown, white, and pink - accounted for 98 per cent of the total landings (7).

Data on the Gulf of Mexico shrimp distribution are compiled by the Bureau of Commercial Fisheries Exploratory Fishing Base, Pascagoula, Mississippi. For statistical reporting purposes, the Gulf of Mexico is divided into 40 statistical areas. Each statistical area is further divided into depth zones of 5 fathoms each (0-5, 6-10, 11-15, etc.). Shrimp catch statistics are reported in Gulf Coast Shrimp Data, by statistical area and depth zone. The zone comprising the Breton Sound area is statistica area number 12.

Although nine species of shrimp of the family Penaeidae contribute to the extensive Gulf of Mexico shrimp fishery, only brown shrimp, Penaeus aztecus; white shrimp, P. setiferus; and pink shrimp, P. duorarum, are caught in significant numbers. These species all have a similar life cycle in which spawning occurs offshore.

Eggs are laid directly into the water and are apparently fertilized by spermtozoa, contained in a capsule (spermatophore) that the male attaches to the female. A female lays 500,000 to 1 million eggs at a spawning - some females probably spawn more than once a season. Most, if not all, spawning takes place at sea, mainly from late March or early April to the end of September.

The eggs are about 1/75 inch in diameter and demersal. Eggs hatch in about 20 to 24 hours, and the nauplius, which resembles a tiny mite, emerges and becomes planktonic drifting about and feeding chiefly upon microscopic phytoplankton (diatoms, etc.). Within two weeks after hatching, the young shrimp becomes a postlarva which is an active swimmer and manages to reach the shallow estuarine nursery areas.

Soon after reaching the nursery areas, the postlarva descends to the bottom. Formerly a plankton feeder, it now becomes a bottom feeder, consuming algae, bottom invertebrates, and plant and animal debris. This omnivorous feeding continues through the adult stage. (The larger shrimp feeds on the same type of food as the bottom-dwelling postlarva and early juvenile, except that larger organisms such as worms and mollusks are also eaten).

The bottom-dwelling postlarva soon becomes a juvenile. Growth is very rapid, particularly when water temperatures exceed 70°F. As the shrimp grows, it moves gradually seaward, presumably in response to salinity or habitat preferences. By the time the shrimp is an adult, it is moving out of the estuarine areas into the ocean. Most brown shrimp, which enter coastal waters as postlarvae in winter and early spring, move offshore during late summer and fall; but by late fall practically none remain inshore. Large white shrimp, and to a certain extent pink shrimp, enter inshore waters as postlarvae in late spring and summer and move offshore in late fall and winter. Many juveniles and subadults of these species remain inshore throughout the winter, and spawn the following spring. Temperature and salinity appear to be major influences in the inshore, offshore, and coastwise movement of all these species.

The postlarval catch per 120 minutes of fishing effort in the Barataria Bay area, which lies due west of Venice, Louisiana, has been recorded for the years 1962-1965. These data represent total catch and were not separated by species; however, that portion of the graph from January through May may be considered principally P. aztecus since P. setiferus is not present in numbers until June. As seen in Figure 26, the postlarval population peaks occurred in April in 1962 and 1963, in February in 1964 and in March of 1965. These peak catches apparently represent the major influx of postlarvae into the bay system and should give an indication of the forthcoming shrimp crop.

It should be noted, however, that the total catch as well as the time of the peak occurrence varied considerably for the four-year period. Obviously, the 1962 and 1963 catches were smaller than in 1964 and 1965. However, the greater catches in 1964 and 1965 may, in part, be a result of changes in sampling effort and technique which included an increase in effort after 1962 and a revision of the sampling time to fish the incoming tide after 1963. Though these two changes in sampling technique may have caused some increase in catch efficiency, nevertheless, it appears that the higher catches in 1964 and 1965 represent a significant increase of postlarvae on the nursery groups during these two years and should have resulted in a measurable increase in production. This, however, was not necessarily the case. An analysis of the data for 1962 and 1963 suggested an almost direct relationship between the postlarval catches and landings (Louisiana Wildlife and Fisheries Commission, 1964).

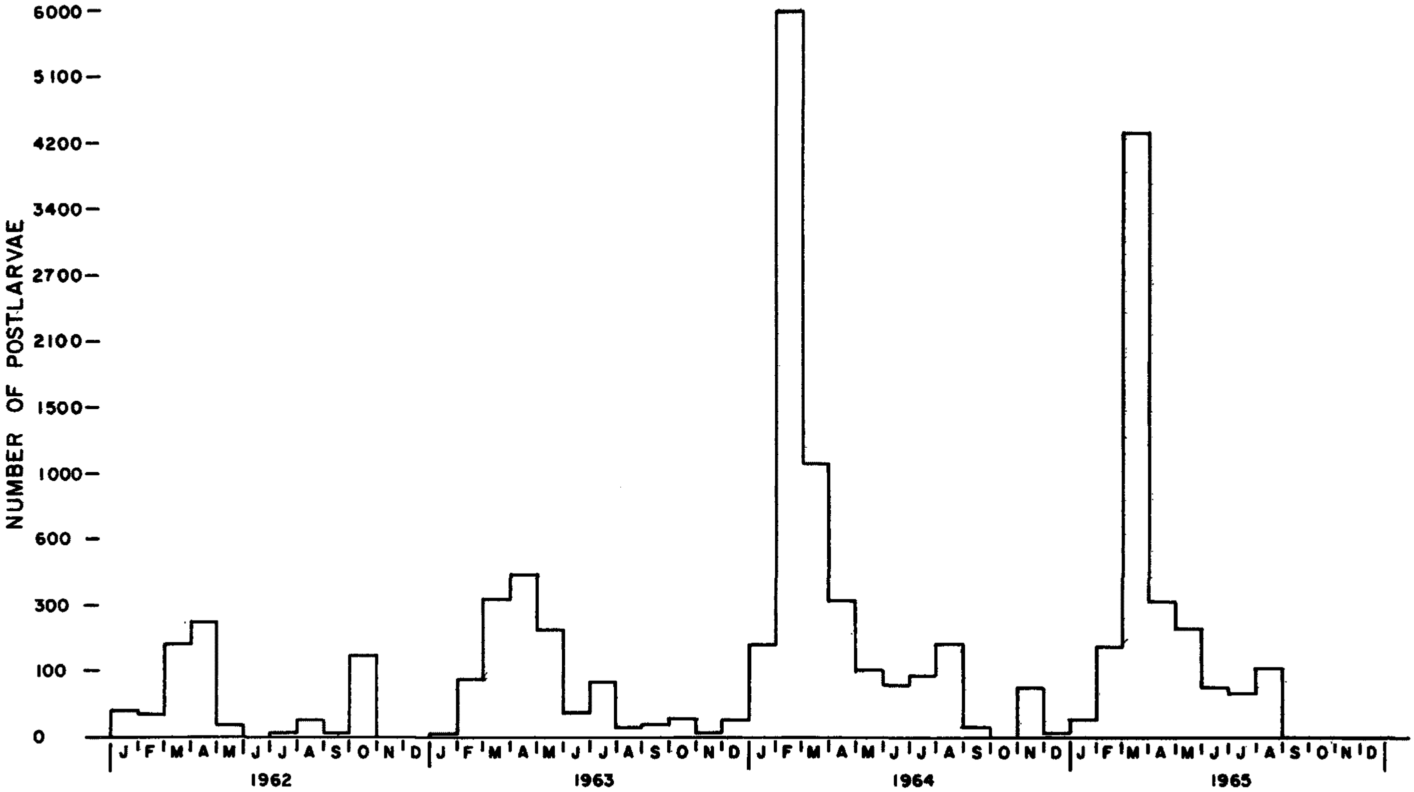


FIGURE 26 - POSTLARVAL CATCH / 120 MINUTES OF EFFORT: FOUR BAYOUS, BARATARIA AND CAMINADA PASSES.

When the data for 1964 and 1965 were considered, the same relationship did not exist. In this latter case, apparently heavy movements of postlarvae into the nursery area did not result in as high a production as might have been expected had the correlation occurred in 1964 and 1965 as existed in 1962 and 1963. This suggests that the directness of relationship between postlarval catches and landings is governed by other factors which probably increase or decrease the mortality rate of postlarvae after they arrive on the nursery grounds. While it may take an analysis of many shrimp cycles in relation to environmental parameters to establish the exact causes of postlarval mortalities, it seems evident from these data that conditions in 1962 and 1963 were far more favorable to postlarval survival than in 1964 and 1965.

Many species of fish and other animals prey upon shrimp during the various stages of their life cycle. Eggs and early larvae are consumed by predators such as arroworms and larval fishers; postlarvae and early juveniles are preyed upon by postlarval and juvenile fishes such as croaker, spot and flounder. Larger shrimp are eaten by many enemies, chief among which are the seatrouts, silver perch, and other sciaenid fishes.

The large and highly mobile shrimp fleet comprises trawlers of distinctive design and similar construction that are capable of locating and fishing concentrations of shrimp throughout the Gulf of Mexico. The average offshore trawler has a length of about 60 feet, a capacity of 50 gross tons, and a main engine of about 160 horsepower. The offshore fleet totals about 2,000 vessels. Some of the smaller vessels are rigged to tow a single trawl from the stern; however, most offshore trawlers are equipped to tow two smaller trawls, one from each side. The latter are termed "double-rig" trawlers. Gulf of Mexico shrimp trawls are quite uniform in shape and dimension and have three basic designs: the flat trawl, the semi-balloon trawl, and the balloon trawl. The size of the trawl (measured as the width along the footrope) varies with the size and power of the individual vessel, but most single-rig vessels use 90 to 100 foot balloon or semi-balloon trawls, whereas most double-rig vessels use 40 to 45 foot flat trawls. In addition, almost every shrimp trawler is equipped with a 10-foot "try" net that is towed from the stern.

Catches are sorted and iced down aboard the vessel and landed as 100-pound "boxes" of shrimp. If the individual shrimp are large and catches are moderate, the shrimp are headed before icing and delivery to the shore plant. During periods of extremely high catches, however, the shrimp taken on grounds near the port of landing may remain unheaded until final processing ashore. Brown shrimp are widely distributed over the continental shelf in the Gulf of Mexico. The brown shrimp fishery is centered in the northwestern Gulf of Mexico; the largest commercial catches are made on the sand and mud bottoms off the coast of Texas. Brown shrimp are caught, at least in small quantities, along the coast of the Gulf of Mexico - from northern Florida to the Yucatan Peninsula of Mexico. Brown shrimp are caught at night when they come out of their burrows. During daylight they are burrowed in the bottom and are not caught by fishing gear. Vessels fishing for brown shrimp are generally the large,high-powered, well-equipped, and double-rigged vessels. They move considerable distances along the coast to harvest the shrimp where they are seasonally abundant.

Of the three major species, brown shrimp ranked number one in pounds landed during 1959-1963 (8). This large fishery is relatively new, for it did not begin to develop until the end of World War II. White shrimp had dominated the landings, and brown shrimp, although present in great abundance, were difficult to market because of their darker color. With the decline of white shrimp landings in the late 1940s, the Government and industry increased their efforts to promote the marketing of brown shrimp and the fishery developed rapidly. The first commercially important catches of brown shrimp were made off the Texas coast in 1947.

White shrimp have about the same geographical range in the Gulf of Mexico as the brown shrimp. The Gulf fishery, however, is centered on the mud and sand bottoms off the coast of Louisiana in the north-central Gulf of Mexico.

Unlike brown and pink shrimp, white shrimp apparently do not burrow into the bottom during the day, for the largest catches of white shrimp are made in daylight. White shrimp may be taken occasionally at night along with brown shrimp, especially during the spring and fall. Generally, the vessels fishing for white shrimp are single-rigged and are smaller, lower-powered, and more poorly equipped than the vessels that fish mainly for brown or pink shrimp. They are less seaworthy than the larger vessels and move only short distances along the coast where they support mostly local fisheries. Many have shallow drafts that enable them to fish in both the inshore and offshore areas.

White shrimp ranked second in pounds landed among the three major species during 1959-1963. For many years this species supported the entire Gulf of Mexico shrimp fishery. Prior to the mid-1930s it was entirely an inshore fishery, but as markets developed, the fishery moved offshore and developed rapidly to its peak during the mid-1940s, after which time it began a gradual decline in relative importance.

Pink shrimp have an almost continuous distribution throughout the Gulf of Mexico, although consistent commercial catches are made only on the shell, coral sand, and coral silt bottoms of the Gulf of Mexico. Two rather restricted areas, one off southern Florida and the other off the Yucatan Peninsula, produce over 90 per cent of the pink shrimp landings. The catches of pink shrimp from the northern Gulf of Mexico are made at times, usually on a seasonal basis.

Like brown shrimp, pink shrimp come out of their burrows at night, when they are taken in trawls. Most of the vessels used in the pink shrimp fishery are similar to the large, high-powered, well-equipped, and double-rigged vessels of the brown shrimp fishery; however, the same vessels also travel to the distant grounds off the Yucatan Peninsula. Also, many of the same vessels fish seasonally in the brown shrimp fishery. Pink shrimp ranked third in importance among the three major species during 1959-1963. The fishery for this species is the most recent of the three: It began off both southern Florida and the Yucatan Peninsula about 1950.

C.3.4. Gulf Blue Crab Callinectes sapidus

The blue crab, Callinectes sapidus Rathbun, class Crustacea, is a common inhabitant of muddy and sandy shores of the Gulf Coast of North America.

It is caught by many and diverse forms of fishing gear in salty, deep channels of the Bay and in brackish waters of its river tributaries, often quite far up the rivers in water of extremely low salinity. The female mates usually while it is in the soft crab state, but not until after it has shed for the last time.

Having found a mate, the male cradle-carries the female beneath him by hooking his first walking legs and pinching claws between the first walking legs and pinching claws of the female. She is carried two or more days until she sheds her immature shell. While she is shedding, the male hovers over her. After the soft female emerges from the shed she turns over on her back and unfolds the abdomen to expose the two genital pores. Mating may occur day or night and may last from five to twelve hours. Sperm are transported in microscopic, oval-shaped bundles called spermatophores to a pair of sacs in the female called seminal receptacles or spermathecae. Sperm will live in the female receptacles for at least a year, to be used as often as the female lays eggs. After mating, the adult female is again carried, cradle fashion, beneath the male, for another two days or more.

Since the female mates only once, in the soft-shell state or shortly thereafter, the cradle-carry is undoubtedly important to ensure that a male is present at the critical moment of shedding, and to protect the soft female until her shell is hard. Two to nine months may elapse between mating and egg laying by the female. If mating occurs as early as May, the first egg mass may be laid in August. Although most females mature and mate in August and September, and eggs in the ovaries of each female develop almost to completion within the next two months, egg-laying is delayed until the following May or June. Egg laying is rapid and may be complete in two hours, eggs passing from the ovaries to the outside by way of the seminal receptacles where fertilization occurs. Outside the body, the fertilized eggs are attached by adhesives to hairs of four pairs of appendages (swimmerets) on the abdomen.

A few sponge or egg-bearing crabs may be seen before the end of April, but normally the first peak of sponge production occurs during the last week of May and the first two weeks of June.

The number of eggs in a sponge ranges from 700,000 to over 2,000,000. Many of the eggs do not hatch, and still fewer larvae and very small crabs live to become adults. On the average only one ten-thousandth of one per cent (0.000001) of the eggs survive to become mature crabs.

After hatching the young crab passes through two larval stages, zoea and megalops, before it takes the form of a crab. The zoea looks like a shrimp and bears a heavily-spiked hood, while the megalops looks like a miniature toad that still retains its tadpole tail. The zoeal form lasts about a month, during which it molts at least four times, growing from 1/100 to about 1/25 of an inch in width.

Following the fourth (or fifth) molt is the megalops stage. Many of the larvae that hatch in early June reach this stage by mid-July or the first of August. The megalops stage lasts only a few days. When it molts the "first crab" appears, with the typical body shape of an adult crab.

Growth is rapid and adult size may be reached one year to a year and a half after hatching. Those hatched early, in late May, become two and one-half inches wide by November and five-inch adults or larger by August the following year. Those that hatch in late August or September may reach only one-half inch in width the first fall. By November the next year, these will have become only three or four inches wide and will not become adult until May of the third summer. After reaching adult size, crabs are known to live at least one more year, and a few may reach the maximum age of three to three and one-half years. The average life-span, however, probably is less than one year.

The diet of blue crabs includes fresh and decaying fish or meat, as well as vegetation. Roots, shoots, and leaves of common seaweeds are regularly eaten, especially parts of eelgrass (Zostera), ditch grass (Ruppia), sea luttuce (Ulva), and salt-marsh grass (Spartina). Destruction of young quahogs (Venus) and seed oysters (Crassostrea) in experimental ponds and tanks has been frequently reported. On clam and oyster grounds in open waters, however, the blue crab cannot be considered a serious pest, although transplants of young sets may be destroyed when other food is less available.

Fishing methods for blue crab include the use of baited traps and also use of crab dredges.

C.4. Commercially Important Mammals

There is a substantial fur and pet food meat industry in Louisiana centered about the trapping and skinning of muskrat, nutria, raccoon, mink, opossum, skunk, otter, lynx, fox and beaver. Records are compiled by the Fur Division of the Louisiana Wildlife and Fisheries Commission. Of these animals, the most important dollar value for pelts in 1968-1969 season (Table 4) was represented by four species, the muskrat, nutria, raccoon and mink, with the industry as a whole valued at more than $7,000,000.00 for that year (1).

TABLE 4 DOLLAR VALUE FOR PELTS AND MEAT 1968-1969 SEASON IN LOUISIANA

	Animals	Each	Total
Muskrat	1,556,764	$ 1.10	$1,712,440.40
Nutria (Eastern La.)	1,000,000	1.50	1,500,000.00
Nutria (Western La.)	754,028	3.00	2,262,084.00
Raccoon	95,654	2.50	239,590.00
Mink	46,918	5.00	234,590.00
Opossum	9,918	.50	4,748.00
Skunk	250	.50	125.00
Otter	5,426	20.00	108,520.00
Lynx	56	5.00	280.00
Fox	324	3.00	972.00
Beaver	124	5.00	620.00
TOTAL	3,469,462		$6,063,514.40
	Pounds	Each	Total
Nutria Meat	10,500,000	.09	$945,000.00
Muskrat	700,000	.09	63,000.00
Raccoon	400,000	.20	80,000.00
Opossum	60,000	.20	12,000.00
TOTAL	11,660,000		$1,100,000.00
TOTAL MEAT AND PELTS	15,129,462		$7,163,514.00

C.5 Mariculture Operations in Louisiana

Fish culture has the same purpose as agriculture: i.e., to increase, by management, production above that which could be obtained naturally. The term aquaculture refers to culture of freshwater plants and animals for domestic purposes, usually food. Mariculture makes use of brackish or saline waters to culture seafoods such as shrimp and oysters.

Many companies, various of which have large holdings of land and wish to diversify their enterprises, are taking a look at fish farming. The lowering of the oil depletion allowances had prompted certain organizations to investigate multiple land use. Companies moving into aquaculture include United Fruit Company, Ralston-Purina Company, W. R. Grace Company (Prewitt, 1970). Inmost Company and United Pennzoil Corporation are actively involved in fish farming in Louisiana (9).

C.5.1. Culture of pompano Trachinotus carolinus

At Louisiana State University, The Sea Grant Program in cooperation with the Agricultural Experiment Station, is supporting research on the ecology and environmental requirements of the pompano, *Trachinotus carolinus* (10). This fish is being widely advocated as a potential species for mariculture. Interest to date has centered in Florida, where both private concerns and governmental agencies are attempting pompano culture.

The pompano is also found along the coast of Louisiana, where it is one of the most highly prized game and food fishes. It is a gourmet item in restaurants of New Orleans; however, the supply is well below the demand.

In their natural environment pompano usually are found in waters of moderate to high salinity. However, a laborabory study indicated that pompano could be maintained at salinities as low as 1.27 ppt. If this fish can be effectively cultured in waters of low salinities, millions of acres of potentially suitable marshes and estuaries in Louisiana and elsewhere will find a new use.

Salinity level probably would probably not limit juvenile pompano in most of the Louisiana marsh. Nitrogenous wastes, however, could be a problem in pompany culture unless provisions are made to remove such material. Certainly more information is needed about the environmental requirements of pompano before they can be cultured successfully in Louisiana. Among the factors that must receive attention are oxygen, carbon dioxide, pH, nitrogenous wastes, density of fish, temperature, nutrition, pollution and long-term effects of salinity.

C.5.2. Culture of Brown and White Shrimp, Penaus aztecus and Penaeus setiferus.

Pond culture experiments carried out by the Louisiana Wildlife and

Fisheries Commission were started in the spring of 1962 at Grand Terre Island, Louisiana. Brown shrimp, Penaeus aztecus, and white shrimp, Penaeus setiferus, were cultured in 0.25 acre ponds (11, 12). Juvenile and postlarval shrimp, obtained from several sources, were stocked at different rates and several types of feeds were used. Production ranged from 40 to 809 pounds per acre and feed conversion ratios from 1.7 to 9.7. Salinities fluctuated between 16 and 35 ppt. while temperatures varied between 8 and 37°C during the study periods.

Louisiana's Marine Laboratory now has adequate research facilities for pond culture of marine and brackish water animals. In 1968, 16 experiments concerning shrimp feeds, feeding rates and stocking rates were successfully completed in the 0.25 acre ponds. Future research will expand these experiments and will also include spawning and maximum population density studies.

High mortalities occurred in 1967 due to an oxygen deficiency. Because fish kills were happening throughout the area at the same time and because the unfed control pond experienced the highest mortality, this kill could not be directly attributed to overfeeding.

Research on culture of aquatic and marine animals for food is also being conducted by the LSU Agricultural Experiment Station in cooperation with the Sea Grant Program. Curently, special attention is being given to nutritional requirements of invertebrates including postlarval pink shrimp (Penaeus durarum) (13).

C.5.3 Culture of the Louisiana Red Crawfish Procambarus clarki

Crawfish farming in Louisiana is a growing viable industry, contributing at an increasing rate to the overall economy of the state (13). In 1968, reported landings of crawfish in Louisiana were approximately six million pounds, with a value of over $1,000,000 - at best a conservative estimate, in view of the unreported "catch" of wild stock from flooded marsh areas and rice fields. Whereas, the bulk of the crop originally was obtained from these natural sources, artificial impoundments begun 20 years ago, are significantly increasing crawfish production yearly. Since 1965, acreage devoted to crawfish, mainly in the southwest portion of the state, has doubled from 6,000 to approximately 12,000 acres in 1969. This crop, comprising an annual harvest of from 6 to 10 million pounds, is harvested from natural waters, rice fields, and impoundments designed solely for crawfish farming is increasing by hundreds of acres yearly, involving establishment of ponds of 20-40 acre size to those as large as 400-700 acres. Recent studies on salinity tolerances of the red swamp crawfish indicate the feasibility of utilizing additional acres of the less saline coastal areas of Louisiana. There appears to be approximately one and three-quarter million acres of fresh water marsh and about two and one-half million acres of salt water marsh in Louisiana which is suitable for crawfish.

C.6 Ecological Changes, Oyster Grass, Spartina alterniflora - "Die-back" in Louisiana Marshlands

"Die-back" is a term applied to degeneration and death of large areas of Spartina townsendii marshes in England. What appears to be the same condition affects S. alterniflora marshes in Louisiana and possibly elsewhere in North America. (14) Several factors are likely to be involved and it is especially important that the effects of pollution and alteration of tidal regime through dredging be investigated.

Spartina alterniflora marshlands in Louisiana frequently have large areas of standing dead stubble. These killed areas were first noted in the Grand Isle area on November 10, 1968. As of December 31, 1969, no recovery was evident, but a continuing watch is being kept on certain areas to ascertain if new growth will appear. The standing stubble is conspicuous evidence that the areas were recently suitable for Spartina.

It is estimated that as much as 50 per cent of some areas are affected. The importance in estimation of net production of S. alterniflora is obvious. Since this grass has often been cited as one of the more important primary producers in the estuarine ecosystem, this condition should affect the overall productivity in estuaries.

Investigators into the nature of Spartina die-back in Britain have generally come to view the condition as due probably to a change in ecological conditions unfavorable to the growth of Spartina, rather than to disease or parasites. In Louisiana, one possible cause of Spartina die-back may be oil pollution. (14)

There is without doubt much more oil moving about in the marshlands lately, from oil spills, bleedwater discharge, and even from bilgewater and discharge from two-cycle outboard engines. Coatings of oil on the foliage of Spartina might, even in small quantities, lethally affect the oxygen transport, gas exchange, and transpirational mechanisms essential for life.

It is possible that a multiplicity of factors may kill areas of S. alterniflora marshlands, and possibly these may act together in most instances. Better understanding of the range of conditions in which Spartina can grow is essential in any program of estuarine management. It is particularly important to sort out the injurious effects of pollution and artificial alteration of hydrography.

C.7 Biology of Coastal Study Area II

Located within the confines of Area II are oyster seed grounds. These are areas designated for the planting of oyster cultch in three materials for the collection of spat (oyster larvae). The resulting cultches are transplanted by the oyster fishermen on their own beds.

The dominant plant species in this area are: oyster grass, wiregrass and black rush. Widgeon grass, an attractive waterfowl food plant, occurs in small quantities in some of the enclosed ponds and pipeline canals on the west side of the river.

The following table (5) lists species of invertebrate and vertebrate animals collected in Coastal Study Area II in a recent survey. (15)

TABLE 5 INVERTEBRATE AND VERTEBRATE ANIMALS COLLECTED IN COASTAL STUDY AREA II 1966-1967

Scyphozoa

Phizophysaliidae
Man of War - Physalia pelagica
Phizostomatidae
4-Eye Jellyfish - Stomolophus meleagris

Pelecypoda

Ostreidae
American Oyster - Crassostrea virginica
Veneridae
Venus Clam - Venus mercenaria

Gastropoda

Muricidae
Oyster Drill - Thais haemastoma

Cephalopoda

Loliginidae
Squid - Loligunculas brevis

Polycheata

Nereidae
Neris sp.

Crustacea

Cymothoidae
Isopod - Livoneca ovalis
Penaeidae
White Shrimp - Penaeus setiferus
Brown Shrimp - Penaeus aztecus
Sergestidae
Net Clinger - Acetes americanus
Alpheidae
Pistol Shrimp - Alpheus heterochaelis
Grass Shrimp - Palemonetes vulgaris

Squillidae
King shrimp - _Squilla empusa_
Paguridae
Hermit crab - _Pagurus longicarous_
Portunidae
Blue crab - _Callinectes sapidus_
Xanthidae
Stone crab - _Menippe mercenaria_

Asteroidea

Scutellidae
Sand dollar - _Mellita quinquiesperforata_

Chondrichthyes

Pristidae
Smalltooth sawfish - _Pristis pectinatus_
Dasyatidae
Atlantic stingray - _Dasyatis sabina_

Osteichthyes

Elopidae
Ladyfish - _Elops saurus_
Clipeidae
Skipjack herring - _Alosa chrysochloris_
Largescale menhaden - _Brevoortia patronus_
Gizzard shad - _Dorosoma cepedianum_
Threadfin shad - _Dorosoma petenense_
Engralidae
Striped anchovy - _Anchoa helsetus_
Bay anchovy - _Anchoa mitchilli_
Synodontidae
Inshore lizardfish - _Synodus foetens_
Ariidae
Gafftopsail catfish - _Bagre marinus_
Sea catfish - _Galeichtys felis_
Cyprinodontidae
Sheepshead minnow - _Cyprinodon variegatus_
Gulf killifish - _Fundulus grandis_
Longnose killifish - _Fundulus similis_
Poeciliidae
Sailfin molly - _Millienesia latipinna_
Gadidae
Southern hake - _Urophycis floridanus_
Syngnathidae
Gulf pipefish - _Synganathus scovelli_
Northern seahorse - _Hippocampus hudsonius_
Pomatomidae
Bluefish - _Pomatomus altatrix_

Carangidae
Crevalle jack - Caranx hippos
Bumper - Chloroscombrus chrysurus
Leatherjacket - Oligoplites saurus
Lookdown - Selene vomer
Pompano - Trachinotus carolinus
Atlantic moonfish - Vomer setapinnis
Pomadasyidae
Pigfish - Orthopristis chrysopterus
Sciaenidae
Freshwater drum - Aplodinotus grunniens
Silver perch - Bairdiella chrysura
Sand Seatrout - Cynoscion arenarius
Spotted seatrout - Cynoscion nebulosus
Silver seatrout - Cynoscion nothus
Banded drum - Larimus faciatus
Spot - Leiostomus xanthrus
Southern kingfish - Menticirrhus americana
Gulf kingfish - Menticirrhus littoralis
Atlantic croaker - Micropogon undulatus
Black drum - Pogonias cromis
Red drum - Sciaenops ocellata
Star drum - Stellifer lanceolatus
Sparidae
Sheepshead - Archosargus probatocephalus
Pinfish - Lagondon rhomboides
Ephippidae
Atlantic spadefish - Chaeteodipterus faber
Trichiuridae
Atlantic cutlassfish - Trichiurus lepturus
Scombridae
Spanish mackerel - Scomberomorus maculatus
Triglidae
Bighead searobin - Prionotus tribulus
Sphyraenidae
Great barracuda - Sphyracena barracuda
Guaguanche - Sphyraena guachancho
Mugilidae
Striped mullet - Mugil cephalus
Atherinidae
Tidewater silverside - Menidia beryllina
Ploynemidae
Atlantic threadfin - Polydactylus octonemus
Bothidae
Southern flounder - Paralichthys lethostigma
Soleidae
Lined sole - Archirus lineatus
Hogchoker - Trinectes maculatus
Cynoglossidae
Blackcheek tonguefish - Symphurus plagiusa
Batrachoididae

Gulf toadfish - *Opsanus beta*
Atlantic midshipman - *Porichthys porosissimus*

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APPENDIX D - JURISDICTIONAL FACTORS EFFECTING CONTROL OF THE MAIN PASS BLOCK 41 FIELD

In September, 1945, the President issued Proclamation No. 2667 stating the Federal Government's jurisdiction and control of the natural resources of the subsoil and seabed of the Continental Shelf. Executive Order No. 9633, issued simultaneously, placed the natural resources of the Continental Shelf under the administrative jurisdiction of the Secretary of the Interior.

The 83rd Congress passed H.R. 4198 (identified as the Submerged Lands Act), signed into law as Public Law 31 by the President on May 22, 1953. The purpose of the Act is described in its title as follows:

To confirm and establish the titles of the States to lands beneath navigable waters within State boundaries and to the natural resources within such lands and water, to provide for the use and control of said lands and resources, and to confirm the jurisdiction and control of the United States over the natural resources of the seabed of the Continental Shelf seaward of State boundaries.

The Act moved the boundary between Federal and State jurisdiction from the ordinary low-water mark and the seaward limits of inland waters to the seaward boundaries of the States. The seaward boundary of the States was established at a distance of 3 geographic miles from the coast line except offshore Florida and Texas, where the limit was set at 3 leagues (9 geographical miles or approximately 10.3 statute miles) from the coast line. These were the boundaries of the States at the time the State entered the Union or as approved by Congress prior to the passage of the Act.

An action was started December 19, 1955, by the United States against the State of Louisiana to establish its right to the minerals underlying the Gulf of Mexico beyond 3 geographical miles from the Coast line of Louisiana and extending to the edge of the Outer Continental Shelf. Also, an accounting was requested for any sums of money derived by the State from that area after June 5, 1950. On October 12, 1956, the United States and the State of Louisiana entered into an interim agreement that divided the submerged lands into four zones with reference to the Chapman line as shown in Fig. D.1. The Chapman line, named after a former Secretary of the Interior, was intended to represent the ordinary low-water mark and the seaward limits of inland waters along the coast of Louisiana. Since the Louisiana coastal charts were based mostly on 1933 surveys, the line was not definite and was understood, at the time, to be subject to modification. Zone 1 was the seaward area within 3 geographic miles of the Chapman; zone 2 was the area from the seaward limit of zone 1 to 3 marine leagues from the Chapman line; zone 3 was the area from the seaward limit of zone 2 to the seaward boundary line of the State of Louisiana fixed by Act 33 of the Louisiana legislature (called the "Coast Guard Line") and, zone 4 was the area extending seaward of zone 3.

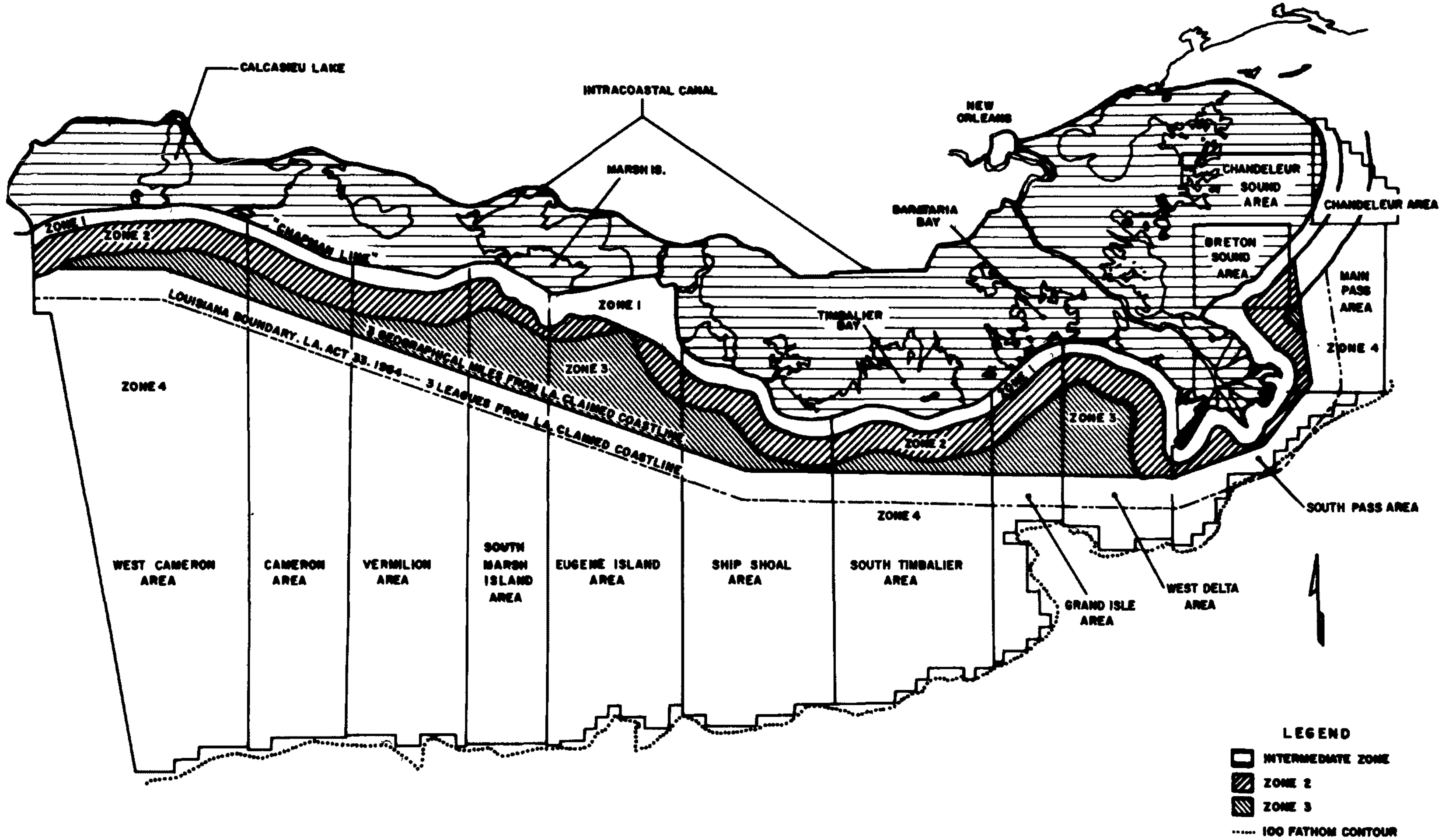

FIGURE 27 — LOCATION OF INTRACOASTAL CANAL, THE CHAPMAN LINE, AND ZONES 1, 2, 3, AND 4, OFFSHORE LOUISIANA.

On May 31, 1960, the Supreme Court delivered the opinion that Louisiana is entitled to rights extending no more than 3 geographic miles from its coast line. The Court denied a request for rehearing on October 10, 1960, and on December 12, 1960, entered its final decree for all five Gulf States.

A supplemental decree rendered by the Court, December 13, 1965, awarded certain disputed areas shown in Fig. D.1. to Louisiana by moving parts of the Chapman line seaward. The decree also moved the seaward limit of zone 3 from 3 leagues to 3 geographical miles from Louisiana's claimed coast line. The acreages in zones 1, 2, 3 and 4 as of October 12, 1956, and December, 1965, are as follows:

	Zone 1	Zone 2	Zone 3	Zone 4
October 12, 1956	930,640	1,833,185	2,848,056	11, 212,568
December 13, 1965	1,083,340	1,388,153	1,465,991	12,889,664

The OCS Lands Act became effective on August 7, 1953, when H. R. 5134 of the 83rd Congress was signed into law as Public Law 212. The purpose of the Act is defined in the title as follows:

To provide for the jurisdiction of the United States over the submerged lands of the Outer Continental Shelf and authorizes the Secretary of the Interior to lease such lands for certain purposes.

The Outer Continental Shelf comprises that part of the Continental Shelf which lies seaward of the portion of the submerged lands along the coast of the United States which Congress granted to the adjacent coastal States in 1953.

Since the location of parts of the Louisiana coast line is still in dispute, MP41C remains in the disputed zone and royalties from this field are held in escrow. However, pursuant to the above regulations, leases that had been issued by the States seaward of State boundaries (as defined in the OCS Lands Act) were validated.

These leases are designated by OCS lease numbers less than 0405. Parts of MP41 are held, then, under validated state leases with the remainder under active Federal lease.

The responsibility for administering the leasing and operating regulations pertaining to OCS mineral resources was delegated to the Bureau of Land Management (BLM) and the U. S. Geological Survey (USGS). The leasing procedures and terms are outlined in Section 8 of Public Law 212.

APPENDIX E

Regional Response Team (RRT)

The Multi Agency Oil and Hazardous Materials Pollution Contingency Plan of the FWQA, South Central Region as represented by the regional response team was alerted and put on a standby basis as of February 11, 1970. The team has representatives from five agencies:

Chairman (FWQA), Mr. W. C. Galegar, Regional Director, South Central Region, FWQA, 1402 Elm Street, Dallas, Texas

Alternate (FWQA), Mr. J. T. Thornhill, Contingency Plan Officer, South Central Region, FWQA, 1402 Elm Street, Dallas, Texas

Executive Secretary (USCG), Capt. L. W. Tibbets, United States Coast Guard Division 8, Custom House, New Orleans, Louisiana

Alternate (USCG), Cmdr. D. H. Dickson, Jr., United States Coast Guard Division 8, Custom House, New Orleans, Louisiana

Representative (U.S. ARMY, CORPS OF ENGINEERS), Mr. J. R. Griffith, Jr., Chief, Operations Branch, U. S. Army Engineers, Lower Mississippi Valley Division, P. O. Box 80, Vicksburg, Mississippi

Alternate (U.S. ARMY, CORPS OF ENGINEERS) Mr. R. A. Naylor, U. S. Army Engineers, Lower Mississippi Valley Division, P. O. Box 80, Vicksburg, Mississippi

Representative (U.S. Dept. of Health, Education & Welfare), Mr. C. W. Northington, Water Hygiene Representative, U. S. Public Health Service, 1114 Commerce, Dallas, Texas

Representative (Office of Emergency Preparedness), Mr. G. W. Hastings, Regional Director, Regional Office 5, Office of Emergency Preparedness, Federal Center, Denton, Texas

Alternate (Office of Emergency Preparedness), Mr. T. B. Sambere, Regional Representative, Regional Office 5, Office of Emergency Preparedness, Federal Center, Denton, Texas

In addition to the regular members of the team, Mr. J. B. Lowenhaupt, Deputy Supervisor, Oil and Gas Branch, Conservation Division Gulf Coast Region, of the U. S. Geological Survey, was present at each meeting concerning the Chevron Oil spill.

During the period from February 11 to February 28, while the team was on a standby basis, daily telephone situation reports were given to each member of the team by the FWQA.

On February 27, the team was activated jointly by the FWQA and the U. S. Coast Guard. Its first meeting was held in New Orleans on February 28 with Mr. Galegar as Chairman. It was decided that the team act only in an advisory and observational capacity since Chevron had taken full responsibility for control and cleanup of oil pollution. Captain Poulter, USCG Captain of the Port, New Orleans, was appointed On-Scene Commander for this incident.

The team met officially on February 28, March 1, 4, 11, 13 and 17. It was de-activated upon closure of this spill incident. (5) All meetings were for informational and review purposes only. Since the team was acting in an observational capacity, no official action was taken affecting efforts to contain the oil.

1 Accession Number

W

2 Subject Field & Group

05C

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

5 Organization

Alpine Geophysical Associates, Inc.
Oak Street
Norwood, New Jersey 07648

6 Title

OIL POLLUTION INCIDENT, PLATFORM CHARLIE, MAIN PASS BLOCK 41 FIELD, LOUISIANA

10 Author(s)

16 Project Designation

Project Number 15080 FTU
EPA, WQR Contract No. 14-12-860

21 Note

22 Citation

23 Descriptors (Starred First)

*Oil, *Oil Wastes, Oil Field, Ecosystems, Environmental Effects

25 Identifiers (Starred First)

*Oil Spill, *Oil Spill Control, Movement of Oil, Oil Surveillance, Biological Damage

27 Abstract

A documentation team from Alpine Geophysical Associates, Inc. observed the Chevron spill incident and interviewed key personnel concerned.

Little damage to the environment was observed, mostly due to a combination of fortuitous circumstances. Considerable knowledge was gained concerning the physical limitations of spill control in open water. (Hirshman-Alpine Geophysical)

Abstractor Julius Hirshman

Institution Alpine Geophysical Associates, Inc.

WR:102 (REV. JULY 1969)
WRSIC

SEND, WITH COPY OF DOCUMENT, TO: WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
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